ESTABLISHING COMPETITIVE PRODUCTION SOURCES

A Handbook for

Program Managers

August 1984

Defense Systems Management College

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The laws and regulations which guide the weapons acquisition process require every program manager to use competition whenever it is feasible and effective to do so. Although the emphasis historically has been on competition during the early phases of the acquisition cycle, the Department of Defense also stresses the importance of competition in production. The program manager must assess the feasibility and effectiveness of production competition in a highly detailed, rigorous, and quantitative way.

These circumstances have led to the development of a production competition handbook. The purpose of this handbook is to provide the program manager and other acquisition officials with a systematic guide to the assessment, implementation, and execution of production competition. The various techniques for establishing competitive production sources are described along with two models to aid the manager in deciding whether or not to pursue production competition on a specific program.

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FOREWORD

The laws and regulations which guide the weapons acquisition process require every program manager to use competition whenever it is feasible and effective to do so. Although the emphasis historically has been on competition during the early phases of the acquisition cycle, the Department of Defense also stresses the importance of competition in production. The program manager must assess the feasibility and effectiveness of production competition in a highly detailed, rigorous, and quantitative way.

These circumstances have led the Defense Systems Management College to sponsor the development of this production competition handbook. The purpose of this handbook is to provide the program manager and other acquisition officials with a systematic guide to the assessment, implementation, and execution of production competition. This handbook represents the combined efforts of ANADAC, Inc., Lanham and Drinnon, Incorporated, and the International Planning and Analysis Center (IPAC).

To enhance the quality of possible revisions to this handbook, you are encouraged to submit comments using the form provided at the end of the book.

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ACKNOWLEDGMENTS

EDITORIAL NOTE

Discussions with several early users of the draft version of this handbook indicate the need to reemphasize a few points. First of all, readers of this publication are reminded that it is a handbook—not a cookbook. As such, its real usefulness is as a guide, providing basic information to which must be added considerable thoughtful analysis of a given program including its product, its schedule, and its contractor and subcontractor base and characteristics. These comments are particularly applicable to Table 3.4-1 (Summary of Preliminary Screen). The reader should not rely on a simple "numerical" summation of the values contained therein. To do so is to oversimplify a complex problem and is hazardous to sound decision making. The "model" contained in Table 3.4-1 should be regarded, like any other model, as only a general approximation of the "real world." In specific circumstances, the reader may choose to disagree with one or more of the values contained in the table--you are, in fact, encouraged to do so. If, for example, the item being procured is highly complex, but a fully validated Technical Data Package (TDP) is available, or can be made available, then the TDP approach may be perfectly acceptable rather than being discarded because of the "X" value shown in the Table. These comments apply to other "prescriptive" aspects of the handbook. Ultimately, the successful implementation of production competition will depend on the thoroughness of the planning effort and the artful application of the principles contained in the handbook.

The authors and publisher wish you success in planning and implementing production competition and hope that the handbook will contribute to that end. Your comments on the handbook, positive or negative, are sincerely desired so that revisions or updates may be made for the benefit of future program managers.

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OVERVIEW

One of the primary responsibilities of a program
manager is the development of an effective acquisition strategy
that reflects cost, schedule, and technical considerations. The
central component of any such acquisition strategy is the use of
competition. The program manager is required by law and
regulation to employ competition, when practicable, throughout
the entire weapon system acquisition cycle, including the
production phase. When applied effectively, production
competition can be a significant aid in controlling or reducing
costs, managing risk, and enhancing technical performance.

Production competition is a complex undertaking,
requiring detailed study and analysis by the program manager.
Many potential benefits have been attributed to production
competition; however, realization of these benefits depends upon
careful early planning and execution. In addition, production
competition may involve several problems, any one of which may
render competition ineffective if not properly addressed.

Despite potential problems, several DoD programs have
employed production competition successfully. The key lessons
learned from these prior efforts are the following:

- Production competition affects every aspect o. the
  program including schedule, budget, contracts, and
  technical performance.

- The success of production competition is determined by program goals and circumstances; there are no textbook solutions.

- Production competition can be employed to influence contractor price behavior, technical performance, and schedule discipline.

When addressing the production competition issue for a particular program, the program manager must investigate the following:

- Whether or not to pursue production competition

- Which technique of echnology transfer is most appropriate, given program circumstances

- How best to implement the chosen technique of technology transfer

- How to utilize effectively the competitive environment once it is established

The program manager faced with these issues could benefit greatly from the experience of prior programs. Unfortunately, the lessons learned on prior efforts have not been documented collectively to assist program managers with future production competition programs. Furthermore, although requiring the use of effective competition, current DoD instructions do not provide detailed guidance on production competition.

These considerations have led the Defense Systems Management College to sponsor development of this production competition handbook, the purpose of which is to provide the program manager with a single reference to use in assessing, implementing, and executing production competition. The handbook combines the lessons learned from prior programs with the key

results of recent research to form a systematic guide to the production competition issue. The handbook is presented in four parts:

Part One: Introduction to Production Competition

This section briefly discusses the importance of the production competition decision, describes various techniques to effect technology transfer, and presents the critical variables associated with production competition.

Part Two: Evaluation of Production Competition

This section presents detailed economic, technical, and program analyses that must be undertaken by the program manager in development of a production competition strategy.

Part Three: Implementation of Production Competition

This section discusses program management actions that can be undertaken to implement effectively a production competition program. Implementation problems encountered on prior programs are discussed, along with alternative solutions to those problems.

Part Four: Execution of Continuous Production Competition

This section presents ways in which the program manager can take advantage of production competition to secure greater contractor cooperation. Issues discussed include production award methodologies, logistic support, product improvement, and capital investment.

PART ONE

INTRODUCTION TO PRODUCTION COMPETITION

1. MOTIV TION FOR COMPETITIVE PRODUCTION

2. TECHNIQUES FOR ESTABLISHING COMPETITIVE PRODUCTION

3. PRELIMINARY SCREEN OF PROGRAMS FOR COMPETITION

1.　　MOTIVATION FOR COMPETITIVE PRODUCTION

The program manager is faced with a myriad of problems and issues associated with fielding a technically superior weapon system in a timely and cost-efficient manner. Increased competition in the acquisition of weapon systems has been advocated as one solution to many of the problems encountered by the program manager. Successful weapon system programs have demonstrated that competition can lead to increased technical performance, reduced acquisition costs, and improved development schedules.

These demonstrated benefits have led to a renewed effort to increase competition in weapon system acquisition. The President, the Congress, the Office of Management and Budget, and the Department of Defense (DoD) are dedicated to obtaining effective competition for defense goods and services. This current emphasis requires the program manager to maintain effective competition through the production phase of a weapon system program, whenever it is practicable to do so.

The program manager should note the emphasis that DoD and the Congress place on the effective use of competition. Competition is not advocated merely for the sake of competition but rather it is advocated as a means to enhance the overall value of weapon systems procurement to the government, considering the economic, technical, schedule, and logistics effects. Thus, when considering the use of competition, the

program manager must assess all relevant factors to ensure that competition is effectively employed.

Production competition is a complex undertaking that influences every aspect of a weapon system program. Thus, the program manager must address the issue of production competition in a rigorous, systematic manner. Unfortunately, the experiences of prior successful programs have never been documented collectively to assist the program manager in addressing the production competition issue.

The purpose of this handbook is to provide the program manager with a single reference to be used in assessing, implementing, and executing production competition. The handbook presents lessons learned from several prior DoD production competition programs and includes reference to recent research.

Prior to assessing the potential for production competition on a particular program, the program manager must have a clear understanding of the current environment relative to competition, the complexity of production competition, and the potential benefits and costs associated with production competition. Therefore, the remainder of this chapter presents the following:

- Recent legislative and regulatory initiatives related to increased competition

- A clear definition of production competition as contrasted with design competition

- The numerous benefits and costs that have been attributed to production competition

- The results of empirical research

- A discussion of the influence of production competition on other aspects of the program

1.1   LEGISLATIVE AND REGULATORY INITIATIVES

Competition in the acquisition of defense goods and services is a legal and regulatory mandate. The DoD and the Congress have long preferred competition as a means of controlling weapon system costs and ensuring a fair procurement system. This preference is expressed through legislation, regulations, and instructions.

Congressional preference for competition in the acquisition of weapon systems is expressed through legislation, such as the Armed Services Procurement Act of 1947. The Act requires that contracts for property or services be formally advertised. Under specific situations, negotiation can be used; however, negotiations must be competitive, whenever practicable. Since 1947, numerous legislative initiatives have been introduced to amend the Act and further increase competition.

Most recently, Congress has expressed specific interest in production competition. Section 797 of the Department of Defense Appropriations Act of 1984, P.L. 98-212, states:

None of the funds made available by this Act shall be used to initiate full-scale engineering development of any major defense acquisition program until the Secretary of Defense has provided to the Committees on Appropriations of the House and Senate:

(a)   a certification that the system or subsystem being developed will be procured in quantities that are not sufficient to warrant development of two or more production sources, or

(b)   a plan for the development of two or more sources for the production of the system or subsystem being developed.

As clearly stated, P.L. 98-212 requires that analysis of production competition be undertaken for all major defense acquisition programs. The program manager, as the single individual responsible for program formulation and execution, must direct the production competition analysis.

These legislative mandates are implemented within the Executive Departments by regulations and instructions that provide the program manager with additional guidance concerning competition. OMB Circular A-109 directs the incorporation of competition throughout a program, especially during the design and development phases. The Federal Acquisition Regulation (FAR) and the corresponding DoD Supplement mandate competition in the procurement of goods and services. FAR Subpart 14.103-1(a) states:

Contracts shall be awarded in accordance with formal advertising procedures whenever feasible and practicable. Except where negotiation is specifically required by this regulation (e.g., foreign purchases by overseas activities), this rule shall be followed even though the existing conditions would satisfy one or more of the circumstances permitting negotiation.

Furthermore, the FAR requires that negotiations be conducted competitively, whenever practicable. Subpart 15.105(a) and (b) of the FAR state:

> Negotiated contracts shall be awarded on a competitive basis to the maximum practical extent. To this end
>
> > (a) Offers shall be solicited from the maximum number of qualified sources consistent with the nature of and the need for the supplies or services being acquired. Acquisition information shall be publicized in accordance with 5.101.
> >
> > (b) Before negotiating a contract on a noncompetitive basis, the contracting officer is responsible not only for ensuring that competition is not feasible and practicable under the existing conditions and circumstances but also for acting whenever possible to avoid the need for subsequent noncompetitive contracts. This process shall include--
> >
> > > (1) Examination of the reasons precluding competition for the current requirements; and
> > >
> > > (2) Taking steps to foster competition in the future, particularly with respect to the availability of complete and accurate data, reasonableness of delivery requirements, and possible breakout of components for competitive contracting.

In March 1984, the Office of Federal Procurement Policy (OFPP) issued Policy Letter 84-2, Subject: "Noncompetitive Procurement Procedures." The letter sets strict limits on agencies' use of sole source contracts, requiring the use of competitive awards except in seven specified circumstances. OFPP Policy Letter 84-2 is reproduced in Appendix F for the reader's convenience; it was implemented in the FAR by FAC 84-3, issued 29 June 1984.

The DoD, through directives and instructions, provides the program manager with additional guidance concerning competition. DoD Directive 5000.1 presents effective competition as one of the primary acquisition management principles:[1]

> Effective design and price competition for defense systems shall be otained to the maximum extent practicable to ensure that defense systems are cost-effective and are responsive to mission needs.

For major systems, DoD Instruction 5000.2 defines the content and structure of the Defense Systems Acquisition Review Council (DSARC).[2] The instruction places heavy emphasis on review of the program's acquisition strategy, including both design and price competition, at major milestones. Although DoD Directive 5000.1 and DoD Instruction 5000.2 emphasize the DoD's preference for competitive procurement, neither document provides det.iled guidance on establishing production competition.

In addition to regulations and instructions, the DoD has initiated several policy initiatives associated with increased competition. The Defense Acquisition Improvement Program, instituted in 1981, includes an initiative to increase competition in the acquisition process. In addition, a High-Level Working Group on Competition has been established

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[1] Department of Defense Directive 5000.1, "Major System Acquisitions," USDR&E, March 29, 1982.

[2] Department of Defense Instruction 5000.2, "Major System Acquisition Procedures," USDR&E, March 8, 1983

under the direction of the Under Secretary of Defense for Research and Engineering. The Group currently is investigating ways to increase effective competition within DoD. Within the services, Competition Advocates have been appointed to encourage competitive procurement practices and to challenge noncompetitive procurements. Furthermore, the services have embarked upon special programs to increase competition in all phases of the acquisition cycle.

In summary, the program manager is required by law and regulation to incorporate effective competition in the acquisition of weapon systems, whenever practicable. Furthermore, the current emphasis on increased competition places additional attention on production competition. Therefore, the program manager must recognize production competition as a critical issue and anticipate consideration of the issue in program reviews and budget justifications.

1.2   TYPES OF COMPETITION

In order to undertake analyses and implementation of production competition, the program manager must have a clear understanding of the concept of competitive production. Competition in defense acquisition is a broad concept that encompasses several procurement techniques and strategies. The program manager should understand two important distinctions

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that delineate this broad concept. First, design competition must be distinguished from production competition.[3] Second, the distinction between different types of production competition, such as buy out and split buy, should be recognized. These distinctions can assist the program manager in applying empirical evidence and theory to a particular program.

Design and Production Competition

Design competition, which occurs during a program's validation or early design phase, involves development of competing solutions to satisfy a mission need. The purpose of the competition is to select the best technical approach within affordable costs.

Design competition generally occurs prior to full-scale development (FSD), when it is unreasonable to solicit binding production cost proposals from the contractors. Probable life cycle costs normally are included in the source selection criteria; however, technical uncertainties associated with the development of a complex weapon system render the cost estimate equally uncertain.

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[3]For a more detailed discussion of this distinction, see Benjamin Russell Sellers, "Competition in the Acquisition of Major Weapon Systems," Naval Postgraduate School, September 1979.

Design competition, according to the carry-over theory
of the 1960s, results in lower total program cost.[4]   The
theory contended that competing firms would generate
cost-effective and technically superior designs.   Proponents of
the carry-over theory develop acquisition strategies that
feature several competing design firms, ultimately leading to a
single FSD and production contractor.   This strategy is
graphically portrayed in Figure 1.2-1.

EXPLORATION	VALIDATION	FSD	PRODUCTION
FIRM A	FIRM A		
UNIVERSITY			
FIRM B		FIRM A (SOLE SOURCE)	
	FIRM B		
GOVERNMENT LAB			
FIRM C			
	FIRM C		
FIRM D			
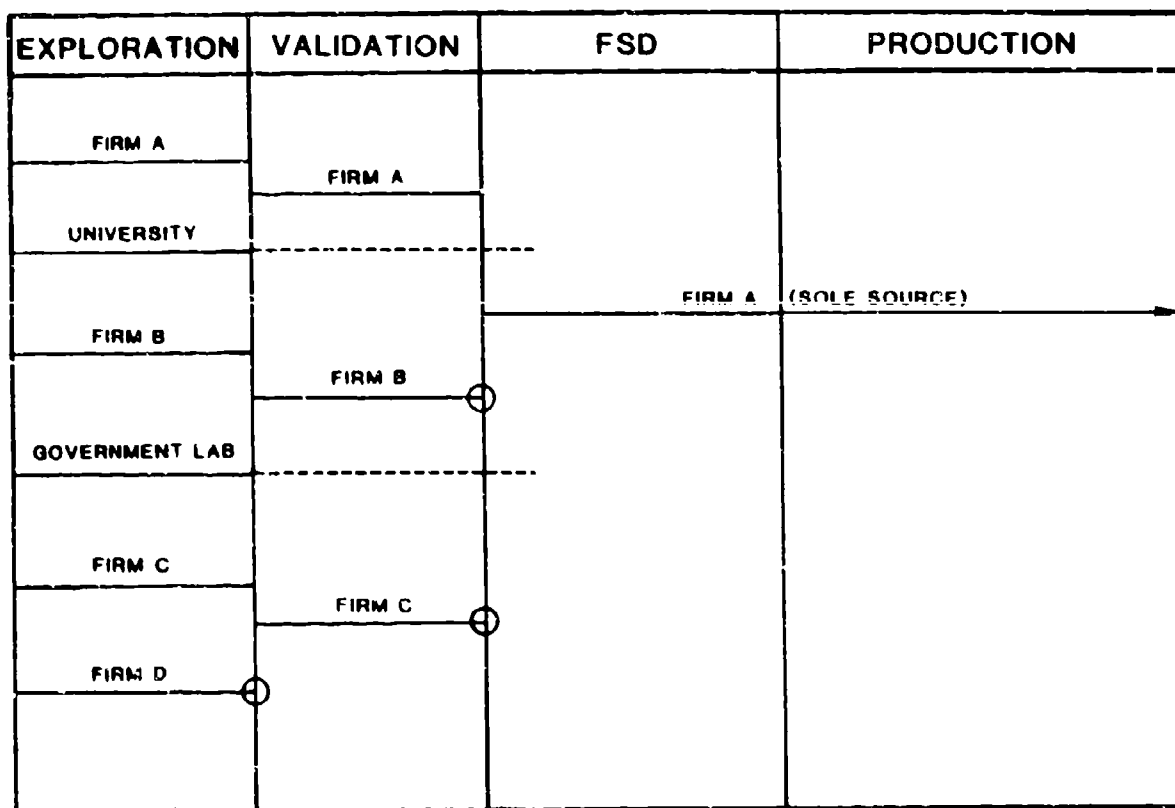
Figure 1.2-1   Design Competition Acquisition Strategy

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[4]Benjamin Russell Sellers, "Competition in the
Acquisition of Major Weapon Systems," Naval Postgraduate School,
September 1979.

The program manager should note that the carry-over approach establishes an intense competitive environment, since only one contractor may proceed with FSD and production. The competing contractors are faced with an all-or-nothing situation.

Several authors have suggested that this intense design competition provides a strong incentive for contractors to propose optimistic cost estimates. They argue that contractors, faced with technical uncertainty in a competitive environment, adopt the most optimistic view and subsequently may propose unrealistic costs. The program office, equally enthusiastic about the program, accepts these optimistic cost estimates. When technical problems arise during FSD, the government has lost its monopsony leverage and must renegotiate with the single source FSD contractor. In such a situation, technical difficulties or contractor proposed technical enhancements often lead to higher development and production costs.

This contention has been supported by recent empirical evidence that suggests single source FSD programs exhibit larger cost growth than competitive FSD programs.[5] Furthermore,

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[5]Lou Kratz and Larry Cox, "Analysis of AMRAAM Acquisition Alternatives: Phase II," The Analytic Sciences Corporation, May 1982.

this evidence indicates that total program cost growth, including both development and production costs, is greater during the FSD phase of a program.[6]

Competition for the best technical design is entirely different from production competition. Production competition involves maintaining multiple suppliers of identical or functionally identical equipment. The goals of production competition are to obtain the lowest fair and reasonable price, to encourage improvements to quality, and to enhance the industrial base. An acquisition strategy featuring production competition is presented in Figure 1.2-2. As shown, the second production source can begin educational and qualification activities during either FSD or production.

The program manager must recognize that design and production competition are distinct. Each has its own goals and each can be undertaken with or without the other. If production competition is to be pursued effectively, its foundation should be laid while the program is under the positive influence of design competition. This may require obtaining data rights, negotiating royalty payments, and defining technology transfer arrangements.

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[6]Louis A. Kratz, et al, "Electronics Cost Research," The Analytic Sciences Corporation, January 1984.

EXPLORATION	VALIDATION	FSD	PRODUCTION
FIRM A			
	FIRM A		
UNIVERSITY			
		FIRM A (SYSTEM DEVELOPER)	
FIRM B			COMPETITIVE SPLIT
	FIRM B		FIRM B (SECOND SOURCE)
GOVERNMENT LAB			
FIRM C			
	FIRM C		
FIRM D			
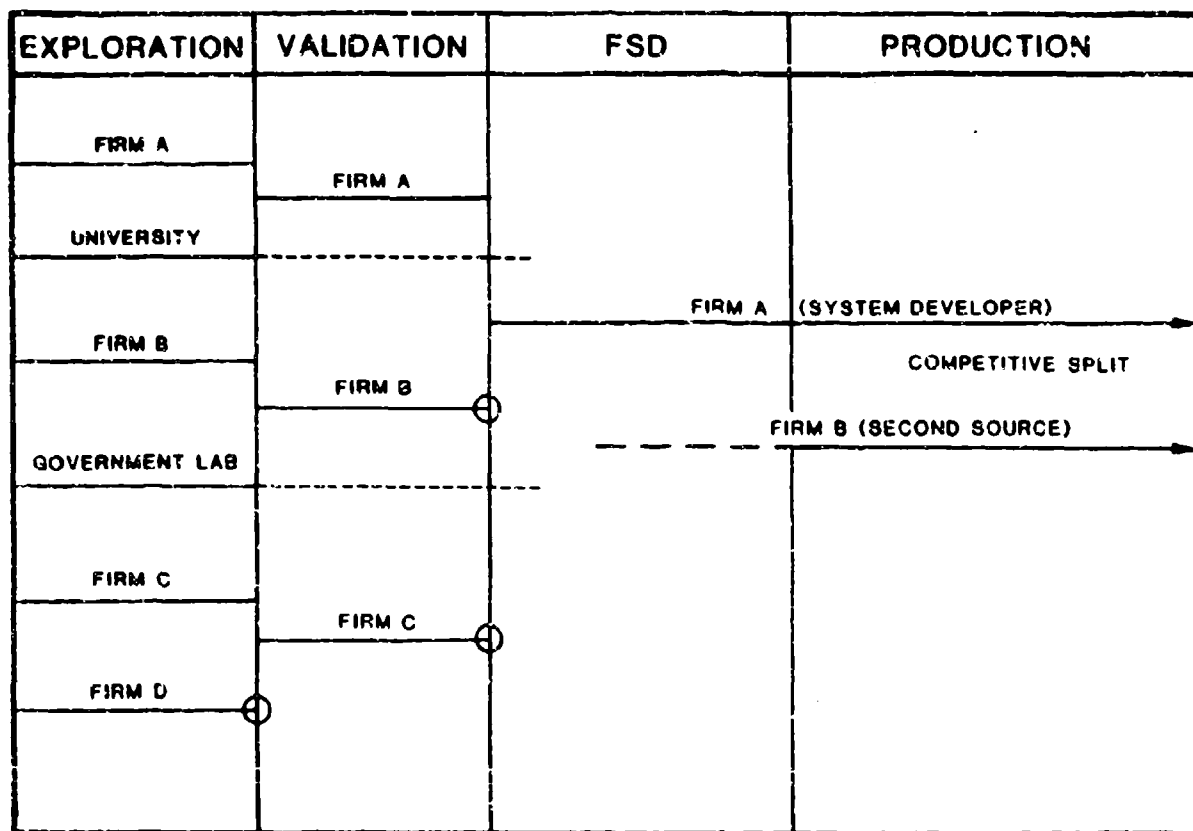
Figure 1.2-2   Production Competition Acquisition Strategy

Production Competition

The acquisition strategy presented in Figure 1.2-2 involves two production sources in continuous competition. The program manager should recognize that other techniques also are

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referred to as production competition. These techniques can be defined along two dimensions: the number of production sources, and the number of competitions undertaken.[7]

The number of production sources refers to the number of sources maintained over time. In some arrangements, the winner of the competition receives all of the production quantity which is up for bid. Thus, only one producer is manufacturing the system at any time. In other strategies, the winner of the competition receives a proportion of the production quantity and the loser receives the remainder. Thus, two or more firms manufacture the system simultaneously. These two concepts can be distinguished as winner-take-all and dual source or split buy.

The other dimension of production competition is the number of times that competitions are held. Production competition can be held once, or there can be several competitions during the production phase. This dimension, in conjunction with the number of production sources maintained, can be displayed in a matrix as shown in Table 1.2-1.

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[7]For a more detailed discussion see, "Quantitative Acquisition Strategy Models," Sherbrooke and Associates, March 1983.

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TABLE 1.2-1
TYPES OF PRODUCTION COMPETITION

Division of Production Quantity	Number of Competitions	
	One	Reprocurements
Winner-take-all	A	B
Dual source	C	D

The program manager must select one type of production competition based upon program goals and circumstances. The benefits and risks associated with the various types of competition are presented in Appendix A. The subject of this handbook is continuous production competition, shown by Case D in Table 1.2-1.

In case D, the production quantity is split between two producers, but the split may be changed through a series of reprocurements. As long as the firms remain competitive in terms of price and quality, they do not face the threat of losing their production quantity entirely. The existence of two up-and-running competitors provides the program manager with considerable leverage in securing contractor cooperation and competitive prices. In the last few years of production, or earlier if one of the firms fails to be competitive, the program manager may conduct a winner-take-all buy out.

A clear understanding of the distinction between the different types of competition enables the program manager to view design competition and production competition as complementary rather than as mutually exclusive. Furthermore, a clear understanding of production competition allows the program manager to apply relevant historical data properly to an assessment of future production competition for a particular program.

1.3   COSTS AND BENEFITS OF PRODUCTION COMPETITION

The DoD has undertaken several competitive production programs. These programs have formed the basis for attributing numerous costs and benefits to production competition; however, the attainment of specific benefits on prior programs does not ensure that those benefits will accrue to future programs. The program manager must recognize that production competition is a complex undertaking, requiring substantial management effort to secure benefits.

The Benefits of Production Competition

Numerous benefits have been attributed to production competition, ranging from decreases in unit procurement cost to increases in equipment quality and industrial productivity. The most often cited benefit has been a reduction in unit procurement costs, leading to overall program savings. Several studies have documented the empirical results concerning this benefit. The results indicate that different cost outcomes have been obtained,

depending upon specific program circumstances.[8] Thus, the program manager cannot rely on a simple savings factor, such as 25 percent, but rather must concentrate on program characteristics.

Competition may provide an incentive for contractors to improve the quality and performance levels of their systems. Furthermore, it has been suggested that in a competitive environment contractors are more likely to propose cost-reducing, rather than cost-increasing design changes. Thus, control of cost growth also has been identified as a potential benefit of competition.[9]

An enhanced industrial base is another potential benefit of competition. Establishing two prime contractors may provide increased surge and mobilization capacity, while lessening the potential for program delays from labor disputes. Furthermore, several authors have suggested that in a competitive environment contractors are more likely to invest in productivity-enhancing capital equipment. It is argued that contractors, by undertaking such investment, may improve their competitive position for future contracts--government and commercial, foreign and domestic.

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[8]See for example: J. W. Drinnon and J. R. Hiller, "Predicting the Costs and Benefits of Competitive Production Sources," The Analytic Sciences Corporation, TR-1511, December 1979.

[9]Louis A. Kratz, et al, "Competition of Defense Procurements: Evidence, Theory, and Application," The 1982 Federal Acquisition Research Symposium, Washington, D. C., May 1982.

A corresponding benefit of competition is a wider geographical dispersion of effort. This diminishes the effect of natural disasters, while enhancing political support for the program.

These various benefits can be summarized by noting that competitive production increases the program manager's leverage. In a competitive production program, the program manager does not face a monopoly supplier. Thus, contractors should be more cooperative and responsive to the needs of the program.

The Costs of Competitive Production

The program manager should recognize that production competition also involves additional costs. The most recognizable cost to the program manager is the increased initial funding necessary for solicitation of a second source, technology transfer, procurement of tooling and test equipment, and qualification testing. These nonrecurring costs are incurred early in the program.

Additional government administrative costs also are required to institute production competition. These costs are associated with second source selection and qualification, recurring solicitations and contract award, and continuous management of two contractors.

Another potential cost of competitive production involves the effect of competitive pricing on contractor investment. It has been argued that competition may lead to reduced contractor profitability, ultimately resulting in a decrease in capital investment.[10] Furthermore, the competitive split buy may lead to excess capacity, further reducing capital investment.

Balancing the Costs and Benefits

The relevance of the various costs and benefits to a particular program depends upon the goals and circumstances of that program. In addition, there is conflicting evidence as to the effect of competition. For example, a cited benefit of competition is an increase in capital investment while a cited cost is a decrease in investment. The program manager must balance the costs and benefits of competition based upon economic, technical, and management analyses that reflect program characteristics.

Additionally, the program manager must keep in mind that the question of whether or not to establish competitive production sources is largely an investment decision: what are

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[10]M. N. Beltramo and D. W. Jordan, "A Brief Review of Theory, Analytic Methodology, Data, and Studies Related to Dual Source Competition in the Procurement of Weapon Systems," Science Applications, Inc., August 1982 (hereafter referred to as SAI-82).

the expected returns on the large expenditures required to establish competition? As in any investment analysis, consideration must be given to alternative application of the investment dollars. For example, the program manager should be prepared to explain why the government's interests would not be better served by increased DoD investment in the developer's capital equipment. Or, why would it not be better to increase the developer's rate to its most efficient point? The point is that the program manager considering production competition must analyze an array of strategies when developing the program acquisition plan.

1.4   EMPIRICAL RESEARCH

As discussed in Section 1.3, one of the benefits of production competition is a reduction in unit procurement costs. Numerous studies of competition have been undertaken based upon different data sets and different methodologies. Several of these studies are summarized in Tables 1.4-1, 1.4-2, and 1.4-3.

TABLE 1.4-1
ESTIMATED PERCENTAGE SAVINGS DUE TO COMPETITION
MISSILES AND MISSILE COMPONENTS

Equipment	IDA-74	APRO-78	IDA-79	TASC-79	SAI-82
TOW Missile	48.1	8.5	8.9	12.3	11.0
DRAGON Round		2.7		2.8	
SHILLELAGH	-0.2	5.9	-8.0	9.4	-10.4
TALOS (G&C unit)	42.3		40.8	39.8	
BULLPUP 12 (Martin)	13.9		31.7	26.5	25.8
BULLPUP 12 (Maxson)	45.8				
SIDEWINDER AIM-9D/G			-4.6	0.7	-22.0
SIDEWINDER AIM-9B			1.6	-5.6	
Standard Missile MR RIM 66A			-4.2	59.2	
Standard Missile ER RIM 67A				34.0	

TABLE 1.4-2
ESTIMATED PERCENTAGE SAVINGS DUE TO COMPETITION
TORPEDOES AND BOMBS

Equipment	IDA-74	APRO-78	IDA-79	TASC-79	SAI-82
HAWK Motor Parts	6.4		45.7	49.9	
TOW Launcher		30.2	44.2	30.2	
DRAGON Tracker		12.0		12.3	
SPARROW AIM-7F (G&C Unit)					-31.4
MK-48 Torpedo Warhead	53.2			48.6	
MK-48 Electric Assembly	37.5			47.0	
MK-48 Exploder				61.2	
MK-48 Test Set				61.8	
Rockeye Bomb			-23.0	-4.5	3.7
MK-46 Torpedo Airframe & G&C					-36.4

Note: IDA-74 is footnote 12, APRO-78 is footnote 11, IDA-79 is footnote 13, TASC-79 is footnote 14, and SAI is footnote 10.

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TABLE 1.4-3
ESTIMATED PERCENTAGE SAVINGS DUE TO COMPETITION
ELECTRONIC PROGRAMS

Equipment	IDA-74	APRO-78	IDA-79	TASC-79	SAI-82
FAAR Radar		16.6		16.6	
FAAR TADDS		18.2		18.2	
AN/ARC-131		-2.1		-16.2	
UPM-98 Test Set		3.0		11.5	
PP-4763/GRC Power Sup		.3		.5	
TD-204 Cable Combiner	52.5		46.8	40.2	
TD-352 Multiplexer	57.8		58.0	55.6	
TD-660 Multiplexer	30.2		38.3	28.4	
60-6402 Elec. Cont.	57.0		49.4	52.7	
SPA-66 Radar Ind.				-3.4	
APX72 Airb. Transp.	32.6		27.1	23.3	
AN/ARC-54			55.0	63.1	
AN/PRC-77		34.8	20.5	41.9	
AN/GRC-106			43.3	41.8	
AN/GRC-103			58.7	60.1	
AN/APM-123			61.2	67.7	
SPA-25 Radar Ind.	21.3		48.8	10.7	
USM-181 Test Set	36.0		56.0	36.3	
FGL-20 Teletype	32.0		23.7	39.9	
MD-522 Mod/Demod	60.3		58.6	51.9	
CV-1548 Signal Conv	53.7		64.0	45.4	
AN/ARA-63 Radio				57.9	
AN/SQS-23 208A Transd.				32.2	
AN/PRL-25				55.0	
AN/ASN-43				10.7	
AN/FYC-8X				43.2	
MK-980/PPS-5			56.0	66.5	
PRT-4			42.3		
Aerno 42-0750			54.8		
Aerno 42-2028			19.9		

The key point from Tables 1.4-1, 1.4-2, and 1.4-3 is
that savings attributed to competitive production cannot be
viewed as a simple factor, such as 25 percent. Savings figures
result from specific program characteristics. Additionally,
different methodological approaches to calculating the savings
indicate different results.

Fortunately, several recent efforts have focused on
specific case reviews of contractor price behavior in a

competitive environment. Efforts by Lovett and Norton,[11] Zusman,[12] and Daly[13] have demonstrated that competition positively affects contractor price behavior. (These studies are summarized in Appendix B.) These efforts have led to the evolution of a common framework that can be used by program managers to estimate the potential price effect of competition.

The framework is based upon the effect of competition on the original producer's price behavior, as evidenced by progress curves. The framework postulates that establishment of production competition leads to both an immediate price reduction and to subsequent price reductions which are greater than would have been obtained with the single source. These ideas are characterized by Drinnon and Hiller as a downward shift and a steepening, or downward rotation, of the progress curve, as presented in Figure 1.4-1.[14]

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[11]E. T. Lovett and M. G. Norton, "Determining and Forecasting Savings from Competing Previously Sole Source/ Noncompetitive Contracts," Army Procurement Research Office, APRO 709-3, October 1978. (APRO-78)

[12]M. Zusman, et al, "A Quantitative Examination of Cost Quantity Relationships, Competition During Reprocurement, and Military versus Commercial Prices for Three Types of Vehicles," Institute for Defense Analysis, Program Analysis Division, Study S-429, March 1974. (IDA-74)

[13]George G. Daly, et al, "The Effect of Price Competition on Weapon System Acquisition Costs," Institute for Defense Analyses, P-1435, September 1979. (IDA-79)

[14]J. W. Drinnon and J. R. Hiller, "Predicting the Costs and Benefits of Competitive Production Sources," The Analytic Sciences Corporation, TR-1511, December 1979. (TASC-79)
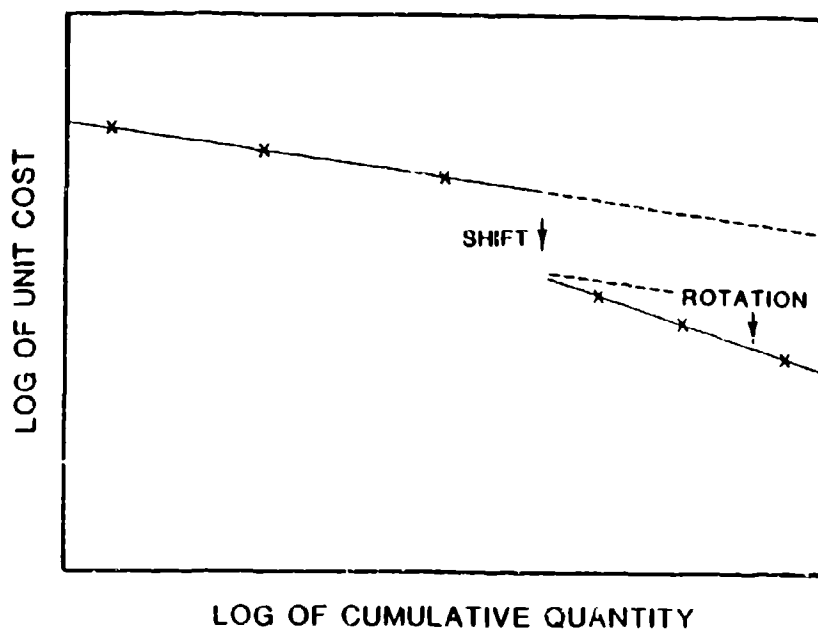
Figure 1.4-1   Framework for Assessing Production Competition

The framework presented in Figure 1.4-1 can be used by the program manager to conceptualize price behavior in a competitive environment. The framework is intuitively appealing, in that one would expect prices to decline in a competitive environment, relative to a single source environment. Several researchers have applied or expanded the shift and rotation formulation. For example, Bemis applied a similar formulation to an analysis of the High Speed Anti-Radiation Missile (HARM).[15]

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[15]John C. Bemis, "HARM Missile Competition Analysis," Office of the Under Secretary of Defense Research and Engineering (Acquisition Management), Contract Administration, July 1982.

Most recently, Kratz incorporated consideration of production rate variations on unit price and presented additional cases of changing price behavior.[16]

1.5   OTHER EFFECTS OF PRODUCTION COMPETITION

Production competition is a complex undertaking that affects every aspect of the program. Prior competitive production programs provide valuable lessons learned in the following areas:

- Program office staff
- Schedule
- Capital investment
- Funding
- Technical specification and performance
- Contracting

The program manager should note that the influence of competition in these areas presents potential opportunities to take advantage of the competitive environment, as well as potential problems.

For example, production competition may require additional program office administration and personnel. The program manager must recognize that this is not merely a matter of additional staff. Successful production competition requires a dedicated management team. Obtaining such a team is difficult

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[16] Louis A. Kratz, "Dual Source Procurement: An Empirical Investigation," The Analytic Sciences Corporation, EM-223-WA, August 1983.

when faced with DoD personnel constraints. Furthermore, increases in program office staff may lead to coordination difficulties, due to the complexity of a larger organization.

The program manager must recognize that the process of selecting and qualifying the second producer may affect the program schedule. Additional development time may be required to qualify the second source, and the production schedule may have to be adjusted to accommodate second source qualification.

The existence of two suppliers also presents the program manager with several opportunities. For example, two suppliers could be used to ensure the successful development of a critical subsystem. In production, two sources could absorb an accelerated production schedule more readily than a single supplier.

This latter opportunity assumes the contractors possess adequate facilities. Facility levels and capital requirements are difficult to determine in a competitive production program. The program manager must assess the desired level of capacity at two plants with limited knowledge of how many units eventually will be produced in each specific plant. Furthermore, the program manager must address the issue of contractor versus government funding of capital equipment.

In addition to potential capital costs, the program manager also must identify required funding for other nonrecurring costs that are incurred early in the program. For example, funds must be obtained to provide for technical data rights and transfer, selection of the second source, and qualification of the second source. These costs and their effects on program funding profiles are recognized by OSD, as evidenced by Deputy Secretary of Defense Memorandum on Programming and Investing for Competition.[17] The memorandum requests the services to identify the additional funding required to establish production competition for promising programs.

The funding issue extends into recurring costs also. In support of the Program Objective Memorandum (POM) and Five Year Defense Plan (FYDP), the program manager must estimate potential production costs under a competitive approach. Often these estimates must be prepared four to five years in advance of the budget year. This situation is complicated further by the critical requirement to identify sufficient funds to ensure successful program execution. Insufficient funds may lead to such a reduction in annual procurement quantities that competitive production is not feasible.

The technical nature of the end item and the technical performance of the contractors also are critical factors that

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[17] William H. Taft IV, "Programming and Investing for Competition," Deputy Secretary of Defense Memorandum 12 March 1984.

must be considered by the program manager. The des re to obtain competitive production may preclude the incorporati of advanced, proprietary subsystems in the design. The item itself may be so complex that even a capable second source would have difficulty producing the item. Furthermore, the second source may not be interested in truly whole-hearted competition, but rather the firm may be content with the smaller share of production. The program manager must recognize the potential for contractor gaming from both sources.

Many of these potential technical problems can be addressed through innovative contracting approaches. Data rights clauses, incentive provisions, and milestone schedules can be incorporated into development contracts to enhance production competition. The program manager should note that this requires early acquisition strategy and contract planning. Once in production, a method must be devised to limit contractor gaming during the split buy award.

These issues are discussed in detail in the remainder of this handbook. The program manager must realize that competition is not a panacea, but rather a complex undertaking. The complexity of the task should not discourage the program manager, for many of the problems encountered on prior programs can be avoided through use of the techniques and tools presented in Parts II and III.

1.6 SUMMARY OF COMPETITIVE PRODUCTION

This chapter has introduced the program manager to the concept of production competition. As the program manager proceeds through this handbook, an increasing level of detail will be presented; however, the program manager should not lose focus of the overriding general principles. Specifically, the program manager should note the following:

- There is a growing momentum within Congress and the DoD for increased competition, especially competition d ring production.

- This momentum is fueled by the numerous benefits that have been attributed to competition; however, the costs of competition also must be recognized.

- Production competition is a complex undertaking that requires careful planning and analysis.

- Design competition and production competition are distinct but complementary concepts.

- Empirical r earch has yielded diverse results concerning mpetition, indicating a need for analyses that reflect program characteristics.

- A framework has been developed to assist the program manager in that analysis.

2. TECHNIQUES FOR ESTABLISHING COMPETITIVE PRODUCTION

This chapter discusses techniques that have been employed by DoD in transferring production technology and establishing competitive production sources. These techniques include the following:

- Form, Fit, and Function
- Technical Data Package
- Leader-Follower
- Licensing
- Contractor Teaming

Following a brief description of each technique, the advantages and disadvantages of the technique are discussed and an historical example is presented. Applicability of these techniques to lower tier items and suppliers also is discussed. Details on implementation of the particular approaches are presented in Part III.

2.1 FORM, FIT, AND FUNCTION

The Form, Fit, and Function (F^3) technique involves the solicitation of alternative suppliers based upon performance and external interface specifications, allowing design and manufacturing flexibility. Potential second sources are provided with functional specifications regarding overall performance, size, weight, external configuration, interface requirements, and

mounting provisions. Once selected, the second supplier is given total design freedom concerning the internal configuration of the equipment.

Advantages of the F^3 Technique

The primary advantage of the F^3 technique is that it does not require a detailed data package.[1] Thus, the government need not validate and maintain a design package. Furthermore, the government need not assume responsibility or liability for technology transfer. The second source contractor is responsible for the item design. If the end item does not meet specifications, the contractor must alter the design.

This method also maximizes the potential production unit cost reduction due to competition, because each firm can design the system based upon its manufacturing process. The second source is not constrained to manufacture to the developer's internal design.

Disadvantages of the F^3 Technique

The F^3 technique also presents several disadvantages. The second source must undertake a system

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[1] For a more detailed discussion of the advantages and disadvantages of the various technology transfer techniques, see: Benjamin Russell Sellers, "Competition in the Acquisition of Major Weapon Systems," Naval Postgraduate School, September 1979.

development program. For more complex items, this may require
considerable effort in time and money, thus delaying the
initiation of competitive awards.

In addition, since the design of the second source's
item is different from that of the original producer, the second
source's end items must be qualified on unique test equipment.
Furthermore, special tooling may be required for manufacture.
Thus, the F^3 technique may involve two different sets of
tooling and test equipment.

The F^3 technique also leads to multiple
configurations of the end items in the inventory. This may
increase logistics costs by requiring two sets of test equipment
and different spare parts. In addition, the end item
manufacturers may be able to exercise monopoly pricing on spare
parts, since they each provide unique configurations.

The F^3 technique also presents the risk that in a
competitive environment the contractor with the least
appreciation for the complexity of the system may be the low
bidder. Once awarded production quantities, this contractor may
encounter significant problems. The program manager can avoid
this problem by carefully constructing the source selection
criteria to highlight contractor awareness of critical elements.

An Example F^3 Program

One recent example of the F^3 technique is the
GAU-8/A 30-millimeter ammunition, managed by the A-10 System
Program Office. Aerojet Ordnance and Manufacturing Company
developed the 30-millimeter ammunition for the GAU-8 under
subcontract to General Electric, the gun system developer.

Based upon DSARC II guidance in 1974, GE developed
Honeywell as a second production source for the ammunition, to
reduce procurement costs and to ensure an adequate supplier base.
GE transferred the required technology based upon the technical
specifications of the gun system. Initial production was
achieved by Honeywell under subcontract to General Electric.

The A-10 program office initiated direct, competitive
buys from the two ammunition suppliers in FY77. The program has
been successful in lowering procurement costs and ensuring an
adequate supplier base.[2]

2.2 TECHNICAL DATA PACKAGE

The Technical Data Package (TDP) technique of
establishing a second production source involves the solicitation
and selection of a second source based upon a stand-alone

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[2]Darrell R. Hoppe, "Dual Awards and Competition--
You Can Have Both," Seventh Annual Acquisition Conference,
Hershey, Pennsylvania. 1976.

technical data package. The TDP is procured by the government from the original developer, either by exercising a rights-to-data clause in the developer's contract or by effecting a separate procurement. Four steps are associated with technology transfer under a TDP technique:

- Preparation of the TDP by the system developer.

- Validation of the TDP by the program office.

- Acceptance and translation of the TDP by the second source.

- Second source qualification and fabrication based on the TDP.

The key to successful technology transfer is an adequate TDP which would define the following technical aspects of the end item:

- Specific requirements of the product in terms of detailed physical and performance characteristics within the operational environment for which the product is intended.

- Quality assurance provisions, including sampling plans and acceptance criteria, acceptance inspection equipment, examinations, and tests to be conducted.

- Preservation, packaging, and packing to ensure adequate and economical preparation for delivery and protection of the product from the time of production to time of deployment.

- Manufacturing instructions or descriptions to ensure that contractors in the general field of capability can expeditiously initiate production of the item covered by the TDP

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[3]For a more detailed discussion of the TDP technique, see: "Technical Data Package Development and Management," Army Management Course, United States Army Management Engineering Training Activity, October 1982.

Advantages of the TDP Technique

The TDP technique of establishing competitive production sources presents several advantages. The program manager can use a valid TDP repeatedly to maintain competition throughout a production program. In addition, by procuring a TDP the program manager maintains the potential for future competition while committing only a small initial investment. This is particularly attractive because the original producer may offer lower prices as a step towards avoiding competition. Thus, the program manager may be able to realize the benefits of competition without incurring the additional tooling and qualification costs associated with competitive production. For this approach to be effective, the first producer must believe that the TDP is adequate and that potential competitors exist.

Disadvantages of the TDP Technique

The TDP technique also presents several disadvantages. In order to validate the TDP, the program manager must have access to a qualified engineering team. This team may be required to function through initial production to ensure resolution of any data package problems.

By validating and releasing the TDP, the government assumes responsibility for its adequacy. Thus, if the TDP is insufficient to enable the second source to produce, possibly

because of inadequate drawings or differences in production processes, the government may be liable.

Given the complexity of modern weapon systems, it may be difficult to document weapon system technology strictly through drawings. Even when drawings are complete and accurate, technological differences between the two companies' manufacturing methods may preclude the second source from manufacturing strictly from the TDP. The second source may be required to undertake reverse engineering to translate the system design. This may result in later logistics complications if the two designs are significantly different.

An Example TDP Program

One recent TDP competitive production program is the AIM-7F Guidance and Control unit.[4] The AIM-7F is an air-to-air missile featuring semiactive radar guidance and a solid rocket motor. Raytheon, the system developer, experienced design difficulties leading to a slip in the development effort. Subsequently, the Navy decided to introduce a second production source to improve product quality, reduce costs, and to enhance the industrial base.

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[4]For a more detailed summary of the AIM-7F program, see: "Review of AIM-7F SPARROW Second Source Procurement Program," The BDM Corporation, December 1980.

The selection and production qualification of General Dynamics, the second source, required over six years. The lengthy second source qualification effort was in part due to funding deferrals and delays in testing. In addition, General Dynamics encountered several problems in translating the Raytheon data package. Costs associated with establishing the second source in then year dollars were approximately $69 million, including the following:

- $6 million for Raytheon's effort on the TDP.

- $11 million for Naval Weapon Center technical assistance and configuration management.

- $52 million for General Dynamics first articles, production learning of 70 missiles, and tooling.

The AIM-7F production competition program has been judged by many to be a successful undertaking. Several authors have demonstrated that the competition led to significant unit cost reductions.[5] Furthermore, a recent review of AIM-7F reliability has demonstrated improved product quality following the introduction of General Dynamics.[6]

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[5]See for example: James H. Quinn, "The AIM-7F Competition Presentation to the Defense Science Board," Naval Air Systems Command, August 1979.

[6]Lou Kratz and Larry Cox, "Analysis of AMRAAM Acquisition Alternatives: Phase II," The Analytic Sciences Corporation, May 1982.

2.3   LEADER-FOLLOWER

The leader-follower technique of establishing a second production source involves direct contractor-to-contractor transfer of technical data. Subpart 17.4 of the Federal Acquisition Regulation (FAR) states that this transfer can be accomplished by awarding a prime contract to a:

- Leader company, obligating it to subcontract a designated portion of the required end items to a specified follower company and to assist it to produce the required end items.

- Leader company, for the required assistance to the follower company, and a prime contract to the follower for production of the items.

- Follower company, obligating it to subcontract with a designated leader for the requisite assistance.

The FAR considers the leader-follower concept as an extraordinary procurement technique and restricts its use to situations when the following conditions exist:

- The leader company has the necessary production know-how and is able to furnish required assistance to the follower.

- No other source of supply can meet the government's requirements without the assistance of a leader company.

- The assistance required of the leader company is limited to that which is essential to enable the follower company to produce the items.

- Its use is authorized in accordance with agency procedures.

Advantages of the Leader-Follower Technique

The key advantage of the leader-follower technique is the limited government liability associated with technology transfer. Unlike the TDP technique, under the leader-follower technique the program office is not required to validate a TDP. Thus, the government need not assume responsibility for the adequacy of the data. In some cases, a complete TDP is not required.

The program office must monitor technology transfer; however, the direct contractor-to-contractor transfer facilitates the development of the second source while minimizing government involvement in technical data validation. Problems encountered in translating technical data can be solved through direct engineering exchange between the two contractors. In some cases the leader can qualify the follower for production.

Disadvantages of the Leader-Follower Technique

The leader-follower technique also presents several disadvantages. The program manager should note that this technique is limited to those programs where the original system developer can be motivated to be a leader company. Because the developer may be less than enthusiastic about assisting in the establishment of a competitor, the program manager should

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anticipate only limited cooperation from the system developer. To enhance cooperation, innovative incentives may be required.

Another disadvantage of the leader-follower technique is that, if the follower is a subcontractor to the leader, the program office may have limited control over follower selection and technology transfer. Thus, the leader may be able to forestall competition by delaying technology transfer or selecting an incapable follower.

An Example Leader-Follower Program

One ongoing leader-follower program is the Advanced Medium Range Air-to-Air Missile (AMRAAM). The all-weather, beyond-visual-range AMRAAM is being developed to be compatible with the F-14, F-15, F-16, F/A-18, and other U.S. and Allied aircraft. AMRAAM features command update inertial guidance for midcourse control plus an active radar terminal seeker with home-on-jam capability.

The AMRAAM program involved early design competition, employing a five-contractor concept definition phase. Hughes and Raytheon were selected to proceed into validation. This effort included a competitive fly off in which both contractors were to fabricate ten prototype missiles.

Requests for Proposals for Full-Scale Development (FSD) included solicitation of both offerors' leader-follower plans and

identification and pricing of any proprietary data. The source
selection culminated in the award of a fixed price incentive,
firm target contract with an award fee provision to Hughes for
FSD.

Raytheon was selected as the follower for AMRAAM and is
currently learning development and production techniques and
providing technical assistance to the government. Raytheon also
will coassemble test articles and early production missiles. A
separate engineering support contract was awarded to Hughes for
technology transfer to Raytheon. Long lead purchases to support
AMRAAM production are planned for FY84. Competitive production
awards are anticipated to begin in FY88.

It is too early to assess the relative benefits of the
AMRAAM leader-follower program; however, several points should be
highlighted. First, the contractors were asked to prepare
leader-follower plans and to identify and price proprietary data
while they were in a competitive design environment. Second, the
two contractors were selected by the government and are under
prime contracts. Third, the technology transfer activities were
initiated prior to production.

Other programs have enjoyed considerable success with
the leader-follower technique. The Army Missile Command success-
fully implemented leader-follower programs on TOW and SHILLELAGH.[7]

[7] J. A. Muller, "Competitive Missile Procurement,"
Army Logistician, Volume 4, Number 6, November-December 1972.

Net savings attributed to this program are $44.9 million. Successful technology transfer, qualified second producers, and high volume production buys are cited as key factors contributing to its success.

2.4   LICENSING

The licensing technique of establishing competitive production sources normally involves inclusion of a clause in the developer's contract enabling the government to conduct competition for production quantities, select a winner, and appoint him as a licensee. The developer or licensor is directed by the government to provide technical assistance and manufacturing data to the licensee in exchange for royalties or fees.[8]

The program manager must recognize that, if a licensing technique is employed, the system developer retains rights to proprietary data and maintains system responsibility. The developer grants permission to manufacture the system to the licensee through a license agreement. The agreement normally restricts use of the technology to the specific program.

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[8] For a more detailed discussion of licensing, see: Gregory A. Carter, "Directed Licensing: An Evaluation of a Proposed Technique for Reducing the Procurement Cost of Aircraft," Rand Corporation, December 1974.

Early applications of the licensing technique involved the use of a license clause in the developer's FSD contract. Recent licensing efforts, such as the cruise missile engine, have been initiated when no provision was included in the development contract. In addition, recent programs have involved developer selection of the licensee.

Advantages of the Licensing Technique

The licensing technique to technology transfer presents several advantages. The use of a license clause enables the program manager to maintain the potential for competition throughout the production phase of a program. The potential for competition may serve as sufficient motivation to the system developer to control costs, quality, and schedule without actually transferring technology.

In addition, the license approach enables technology transfer to be achieved with little program office involvement. Thus, the administrative burden on the program office is less than the burden associated with other techniques.

Inclusion of the license clause in the development contract establishes the potential for production competition early in the program. Detailed decisions on subcontractors and production splits can be determined as the program evolves.

Thus, the program manager has ensured the potential for competition, while not committing a large amount of funds.

Disadvantages of the Licensing Technique

The primary disadvantage of the licensing technique is that the system developer retains proprietary control over the design. This may complicate selection of the licensee, since the full data package cannot be released. Furthermore, the restrictions placed on the technology inhibit application of the technology to other projects. Thus, under a licensing technique, technical transfusion is slower than under other techniques where the government procures unlimited data rights.

In addition, the use of royalty fees increases the cost of the second source's end items and may preclude the second source from attaining competitive prices. The second source also may be faced with an uncooperative licensor. Under a license approach, motivating the developer to assist the licensee may be difficult.

Finally, under a license approach design accountability could become a complex problem. The program manager may be faced with a situation in which the licensee wins the entire production award but the system developer retains configuration responsibility. In such a circumstance, design accountability could be complex, since the developer is no longer under contract.

An Example Licensing Program

A licensing technique was employed by the Joint Cruise Missiles Project (JCMP) to establish a second source for the cruise missile engine. Approximately 4,000 engines were planned to be produced for the air launched, sea launched, and ground launched versions of the cruise missile. In late 1977, the JCMP initiated efforts to develop a second source to ensure adequate supply of the strategically important engine. Williams Research, the engine developer, could not achieve the projected production rates, due to capacity limitations.

Initially, Williams resisted second sourcing, indicating that the engine incorporated extensive proprietary data. Williams reluctantly agreed to a licensing arrangement and selected Teledyne as the licensee with JCMP concurrence. The license agreement established Teledyne as a subcontractor to Williams. Williams was responsible for technology transfer and production qualification of Teledyne.

The license arrangement allows the government to procure engines from Teledyne, through Williams, when delivery requirements exceed 20 engines per month. The license arrangement also includes the payment of royalty fees to Williams from five percent on the first 500 engines procured from Teledyne, down to zero fee for quantities above 6,000 engines.

The key feature of the cruise missile engine project is the program goal of assured supply. As described, the program is not structured for truly competitive awards; however, the program did succeed in establishing a second supplier, in spite of vigorous resistance by the engine developer.

2.5   CONTRACTOR TEAMING

Contractor teaming involves selecting a team of two major contractors to design and test a system through FSD. Each team member designs and fabricates subsystems and components of the system. The contractors then exchange design and manufacturing data with each other, so that both contractors are capable of producing the entire system. Following qualification, the team is split apart for competitive production.

The contractor team can be established in either of two manners. A prime contract can be awarded to one of the contractors, specifying that a subcontract be awarded to the other team member. This has the disadvantage of establishing one of the team members as a prime contractor. Another method is to allow the contractors to form a separate entity or joint venture, which has the advantage of maintaining both contractors in equally responsible roles.

Advantages of the Contractor Teaming Technique

The teaming technique is attractive because of the direct contractor-to-contractor relationship. Technology transfer is achieved during the development phase, in which each contractor must rely on the other to supply critical subsystems and components. This reduces problems associated with proprietary data claims.

This mutual reliance also provides an incentive for contractor cooperation and enhances qualification of two sources simultaneously. The simultaneous qualification of both producers establishes a competitive environment at the beginning of production. Furthermore, the direct exchange of technical data limits government involvement and liability associated with technology transfer.

In addition, the team development of the weapon system enables the program to benefit from the design talent of both contractors. This may improve the technical characteristics of the system or enhance the development of innovative designs.

Disadvantages of the Contractor Teaming Technique

Associated with the apparent advantages of teaming are disadvantages. Until recently, contractor teaming was viewed with suspicion, due to potential antitrust problems. The program

manager still must consider this potential and seek legal counsel
during the initial development of a teaming approach.

In addition, the contractors may view specific
manufacturing processes as proprietary or trade secrets and thus
not exchange all necessary manufacturing data. Once the team is
split, the contractors have no motivation to continue
cooperating. This potential problem can be minimized by
maintaining the contractor team until both contractors
demonstrate production capability.

The teaming technique is a complex undertaking, even if
the contractors are dedicated to cooperation. The program
manager must anticipate the involvement of two contractor
management structures, provide for review of two facilities, and
consider the potential geographic separation of the development
effort. These factors will increase the administrative burden on
the program office and complicate program management. In
addition, the development effort may be more costly, due to the
involvement of two contractors.

The teaming technique also presents risk that, during
development, the joint venture team may behave as a single entity
and attempt to exercise monopoly power. The program manager must
recognize that the team does represent a single developer and the
benefits of competition may be limited by team actions during
development.

An Example Contractor Teaming Program

The Airborne Self-Protection Jammer (ASPJ) is an ongoing example of contractor teaming. The ASPJ is an onboard defensive electronics countermeasure (ECM) system used in conjunction with a warning receiver and expendable dispenser. The ASPJ will provide an advanced ECM suite for the F-14, F-16, F-18, EA-6B, and A-6E aircraft. As such, the ASPJ is viewed as the major ECM endeavor for the next two decades.

Contractors were asked to team for the ASPJ validation effort to ensure industrial vitality. Three contractor teams competed during the early design phase of the program. The ITT-Westinghouse joint venture was selected to proceed into FSD. ITT and Westinghouse provide key management personnel to the joint venture, and support it through FSD and initial production.

Although it is too early to assess the success of the ASPJ contractor teaming, several key factors should be highlighted. First, the ASPJ program successfully incorporated design competition and production competition by involving multiple contractor teams in validation. Second, the ITT-Westinghouse arrangement involves a joint venture. Third, the team concept was employed on ASPJ for industrial base considerations.

2.6   COMPETITION AT THE LOWER TIERS

There is increasing concern over the effectiveness of production competition at the prime contractor level. This concern arises from the contention that the value added at the prime contractor level is decreasing due to the increasing subcontracted portion of weapon systems. A review of the DoD FY62 procurement of missiles, aircraft, aircraft engines, and electronics indicated that approximately 50 percent of the equipment value was subcontracted for major equipment and material purchases.[9] Recent estimates of the amount of subcontracting on major systems range from 60 to 75 percent.[10]

It is argued that competition at the prime contractor level will have little effect if a large portion of the system is subcontracted, since the contractor would control only a small portion of the cost. Rather, greater production competition of key subsystems has been advocated as a means to maximize the benefits of competition.

The OSD recognizes the potential benefits of increased subtier competition, as evidenced by the Deputy Secretary of

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[9]"Analysis of Extent of Competitive Procurement by DoD Prime Contractors," Logistics Management Institute, January 1964.

[10]"The Economics of Second Sourcing in the Aerospace Industry," Trainor Associates, Inc., April 1983.

Defense Memorandum, "Increasing Subcontract Competition," 5 April 1984. The memorandum identifies a general set of circumstances under which subcontract competition may be employed effectively. These circumstances include the following:

- When there are high-priced components.

- When quantities being procured are sizeable.

- When the requirements for the item are expected to continue for a considerable period of time.

- When it has been assured that the existing subcontractor possesses standard manufacturing techniques required for production of the item and has no proprietary rights for the component being considered. (If the subcontractor possesses exclusive manufacturing techniques or has proprietary rights, downstream subcontract competition may still be pursued if economically feasible or in the interest of industrial mobilization.)

- When to do so would fulfill a need to enhance the industrial base or mobilization capabilities, or when future requirements are expected to exceed planned subcontractor capability.

- When there is a problem, or a potential problem, in performance of the major end item that can be attributed to the subcontracted item. Use of another subcontractor with better manufacturing capability or technical expertise could resolve the problem.

In addition, the memorandum presents five possible methods of increasing subcontract competition. These include:

- Directed Subcontract Second Sourcing - Contract provisions can be negotiated that require competitive purchase of specific subcontracted items. These items can be identified during preaward review of the contractor's "make-or-buy" plan.

- Use of Award Fee Provision - Award fees can be used to motivate prime contractors to increase effective competition at the subcontract level.

These fees should be tied to established subcontract competition goals based upon historical data.

- **More Detailed Analysis of Subcontractor Proposals** - During negotiations, the prime contractor could be required to provide the rationale for not competing subcontractor requirements. Subcontractors whose pricing trends are unsatisfactory could be challenged by the government.

- **Increased Emphasis on Contractor's Procurement System Reviews** - Contract Administration Offices could review prime contractors' procurement systems with the intent of emphasizing needed improvement in subcontractor competition, as well as improved subcontractor negotiations.

- **Source Selection Criteria** - For competitively negotiated contracts based primarily on nonprice considerations, the extent of competition in subcontracting can be made a part of the source selection criteria. This should be in instances when it is determined that effective subcontract competition is both feasible and desirable.

Production competition at lower tiers can be effected in several ways. The prime contractor can conduct the competition, perform source selection, and procure the subsystems. In this case the contractor assumes full responsibility for the equipment and for qualification of the second source. The subsystems are integrated by the prime and delivered to the government as contractor-furnished equipment (CFE).

Another approach to subtier production competition involves greater government participation. The program manager could identify key subcontracted subsystems and break them out for procurement directly from the supplier. The items would then be provided as government-furnished equipment (GFE) to the prime

contractor for integration. This approach enables the program
manager to obtain competitive prices for the subsystem while
reducing the overhead and fee layering of the prime contractor.
The program manager could pursue production competition for the
subsystem by any of the technology transfer techniques.

There are disadvantages associated with the GFE
approach. It may require an increase in project office personnel
to manage the two equipment suppliers, in addition to the prime
contractor. Government administration is further increased by
the requirement to perform acceptance tests of the subsystem. In
addition, gove.nment risk and liability is increased by
government certification of the equipment. If the prime
contractor encounters difficulty in integrating the subsystem,
the government may be held responsible for deficiencies in the
GFE.

Despite these potential problems, subsystems have been
competed successfully in the past. An example of a competitive
GFE effort is the Advanced Concept Ejection Seat (ACES II),
developed in the early 1970s for the F-15, F-16, and A-10
aircraft. Based upon a projected high volume production phase,
the Air Force began planning for competitive production while the
program was still in the competitive design phase.

A leader-follower technique was employed on the ACES
II. Douglas Aircraft, the developer and lead company, prepared a
leader-follower plan as part of its development and initial

production proposal. Weber Aircraft Company selected by Douglas as the follower subcontractor, successfully produced and tested four seats by early 1979. To provide Weber with greater production experience, the Air Force directed that 20 percent of the FY80 and 50 percent of the FY81 procurement quantities be subcontracted to Weber.

The leader and follower contractors competed head-to-head for the FY82, FY83, and FY84 procurements. The source selection decision was to split the requirements and award each source a prime contract. This decision marked the end of the leader-follower concept, as the follower successfully competed with the leader. The Air Force now has two qualified ACES II seat producers.

Subtier competition presents advantages similar to prime contractor competition; however, different implementation approaches should be anticipated by the program manager. The two approaches should be viewed as complementary, rather than as exclusive, methods. For example, one problem encountered on prior prime contractor competitive programs was the reliance of both prime contractors on one supplier for a critical subsystem or component. This potential problem can be minimized by establishing alternative subsystem suppliers and competition at the subcontractor or supplier level.

2.7 SUMMARY OF TECHNIQUES

This chapter has provided an overview of the various techniques that have been used to establish competitive production sources. In addition, the advantages and disadvantages of each technique have been discussed. The importance of subtier as well as prime contractor competition has been reviewed. Recent DoD emphasis on increased competition has been summarized.

The next chapter, Chapter Three, presents the significant variables associated with production competition and the relative assessment of the various techniques in relation to the variables.

3.   PRELIMINARY SCREEN OF PROGRAMS FOR COMPETITION

Production competition is a complex undertaking requiring detailed and rigorous analyses of the economic, technical, and programmatic aspects of a particular program. The program manager would benefit greatly from a simple framework that highlights key variables and identifies critical areas for further analysis.

Such a framework has been developed and published by Sellers and Parry.[1] The framework can be used in a subjective manner by the program manager to conduct a preliminary investigation of the potential for production competition. In addition, it can be used to highlight key areas and to provide the program manager with an understanding of critical variables.[2]

The remainder of this chapter will present an adaptation of the Sellers-Parry framework. The adaptation is intended to provide the program manager with a systematic approach to reviewing the suitability of a program for production

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[1] Benjamin Russell Sellers, "Competition in the Acquisition of Major Weapon Systems," Naval Postgraduate School, September 1979.

Dennis S. Parry, "Second Sourcing in the Acquisition of Major Weapon Systems," Naval Postgraduate School, June 1979.

[2] This framework has been republished by Sellers, "Second Sourcing--A Way to Enhance Production Competition," Program Manager, May-June 1983.

competition. In addition, it can assist the program manager in establishing a relative ranking of the techniques of establishing production competition, based on program circumstances. Finally, the adapted framework can be used to support preliminary planning for production competition.

The variables in the framework include the following:

Economic

- Total quantity
- Production duration
- Progress curve
- Tooling and test equipment costs
- Contractor capacity

Technical

- Technical complexity
- State-of-the-art
- Potential for other applications
- Privately funded research and development

Program

- Maintenance requirements
- Production lead times
- Degree of subcontracting
- Contract complexity

Following a brief definition of these variables, the relationships between the variables and the various techniques of establishing competitive production are discussed.

3.1   ECONOMIC VARIABLES

The economic variables include those factors that would be involved in a cost-benefit analysis. A more rigorous consideration of these variables is presented in Chapter Four. This section presents the relative influence of the variables on the potential for competition. The variables include the following:

- Total Quantity -- In general, the larger the quantity to be procured, the greater the potential for production competition. The total quantity must be large enough to allow the program to recoup the initial investment in the second source.

- Production Duration -- In general, the longer the production phase, the more attractive production competition becomes.

- Progress Curve -- The progress curve represents the relationship between unit cost and cumulative quantity. If unit costs decrease rapidly as cumulative quantity increases, the second source may not be able to compete effectively with the more experienced original producer. Hence, production competition may not be attractive. Conversely, the flatter the first source's progress curve, the greater the potential for production competition.

- Tooling and Test Equipment Costs -- The establishment of a competitive production program frequently will require an investment in special tooling and test equipment for the second source. The more these costs increase, perhaps due to more sophisticated equipment, the less appealing production competition will appear.

- Contractor Capacity -- The availability of production capacity may be an important factor in the production competition decision. For example, a system developer may not possess enough capacity to ensure timely delivery of a strategically important system or subsystem. On the other hand, if the system developer possesses excess capacity,

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splitting the production run may increase costs through increased overhead per unit.

As described, the economic variables are closely related and often interdependent. Furthermore, the program manager must make a subjective assessment concerning the slope of the learning curve and the magnitude of anticipated tooling and test equipment costs. On the other hand, the program manager should have an inventory objective and production schedule. For all variables in this preliminary screen, the program manager should compare the program's values to other similar programs. In this manner, the program manager can judge the relative values of the variables without undertaking detailed economic analysis.

3.2   TECHNICAL VARIABLES

In addition to economic issues, the program manager must investigate the relationship of other critical issues to the production competition decision. The technical characteristics of the weapon system often are crucial considerations in the production competition decision. In addition, the technical nature of the equipment is a primary determining factor of the technology transfer method. The technical variables include the following:

- Technical Complexity -- The complexity of the equipment refers to the number of external and internal interfaces, as well as the degree of software dependency. The more complex the system is, the less appealing production competition appears. Furthermore, technology transfer techniques that involve direct contractor-to-contractor exchange are preferred for more complex systems.

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- <u>State-of-the-Art</u> -- If the technology employed in the system is pushing the state-of-the-art, technology transfer is difficult to effect and production competition is difficult to establish. Extensive assistance from the system developer to the second source may be required to achieve technology transfer.

- <u>Potential for Other Applications</u> -- If the system or technology embedded in the system has potential for other government or commercial applications, industrial interest in the project may be heightened, leading to intense competition between potential second sources. On the other hand, the system developer may resist competition and attempt to protect the firm's interests in the project or technology.

- <u>Privately Funded Research and Development</u> -- The development of modern weapon systems frequently is achieved through a mix of government and contractor funding. Thus, a system developer may have legitimate proprietary claims that must be recognized by the program manager. The greater the contractor investment in the weapon system development, the more difficult it is to secure unlimited rights to required technical data.

A review of these technical variables can provide the program manager with useful insights concerning the relative attractiveness of production competition and the applicability of the technology transfer techniques. For example, if the program manager knows the program involves a complex, state-of-the-art system, the TDP technique may not be applicable. Further analysis of the TDP technique may not be required. These issues are considered in more detail in Chapter Five.

3.3   PROGRAM VARIABLES

In addition to the technical characteristics of the equipment, other program issues may affect the attractiveness of

production competition. These issues include the following:

- **Maintenance Requirements** -- The introduction of a second production source may lead to the fielding of two configurations, thus the system maintenance concept should be reviewed with respect to production competition. Often, the system maintenance concept is not defined early in the program design phase. This allows the program manager to investigate equipment commonality trade-offs between the producers, considering the maintenance concept. If the maintenance concept is defined, the level of equipment commonality consistent with the concept may determine the method of technology transfer.

- **Production Lead Times** -- Production lead times are a key determinant of the timing of initial production competition. Once qualified, the second source cannot be requested to bid competitively before producing the end items at rate and delivering such items. If production lead times are long, the initial competition may be delayed and competition becomes less attractive.

- **Degree of Subcontracting** -- The degree of subcontracting also may be a key production competition decision variable. Lower tier constraints may force both prime contractors to procure subsystems from the same suppliers. This would diminish, but not eliminate, the potential benefits of competition. Similarly, if a large amount of the weapon system is subcontracted, prime contractor competition may be ineffective, since the contractor controls only a small portion of the cost.

- **Contract Complexity** -- The more complex the original production contract is, the more difficult implementing production competition becomes. The use of incentives, warranties, goals, and thresholds on the original contract increase the complexity of establishing a competitive production program. Competition often requires incentives and clauses to be included in the developer's contract. The inclusion of many incentives or goals may force the contractor to trade off selected incentives.

These variables present the key issues the program manager should review in initially addressing the production

competition decision. A more detailed analysis would consider issues such as funding, program advocacy, and scheduling. These issues are discussed in Chapter Six.

3.4   A PRELIMINARY SCREEN

The economic, technical, and management variables can be used by the program manager to investigate the relative attractiveness of production competition and the relative strengths of the various technology transfer techniques. In a preliminary investigation, a detailed consideration of each variable is not possible. In fact, if the program manager undertakes this preliminary investigation during concept validation, many of the variables will not be defined. This limitation requires the program manager to employ a more subjective approach which allows the identification of critical issues without becoming weighed down in detailed analyses.

The following five-point evaluation system can be used to rank the effectiveness of alternative techniques in relation to the key variables:

- * for a particularly preferred method
- + for strong effectiveness
- 0 for neutral
- - for weak effectiveness
- x for a particularly inappropriate method

The assessments of each variable in relation to the various technology transfer techniques are presented in Table 3.4-1. The program manager is cautioned that the variables are not additive. Any particular variable could either preclude competition or serve as an overriding justification to pursue it. Rather than proposing a deterministic model, the framework presents a simple method that allows the program manager to gain an overall view of the potential effectiveness of production competition in relation to a particular program.

TABLE 3.4-1
SUMMARY OF PRELIMINARY SCREEN

Decision Variable	Form Fit Function	Technical Data Package	Licensing	Leader-Follower	Contractor Teaming
ECONOMIC					
Quantity					
High	+	+	+	+	+
Medium	+	+	0	0	+
Low	0	0	-	-	0
Duration					
Long	+	+	+	+	+
Medium	+	+	0	+	+
Short	0	0	x	x	0
Tooling Cost					
High	-	-	-	-	x
Low	+	+	+	+	+
Progress Curve					
Steep	-	-	-	0	0
Flat	+	+	+	+	+
Contractor Capacity					
Excess	-	-	-	-	-
Deficient	+	+	+	+	+
TECHNICAL					
Complexity					
High	0	x	+	+	±
Medium	+	-	+	+	+
Low	+	+	+	+	+
State-of-the-art					
Pushing	0	x	+	+	*
Within	+	+	+	+	+
Other applications					
Yes	+	0	+	0	+
No	+	+	+	+	+
Private R&D					
High	0	x	0	x	-
Low	+	0	+	+	+
PROGRAM					
Maintenance Requirements					
Complex	x	0	0	0	0
Nominal	+	+	+	+	+
Production Lead times					
Long	-	-	-	-	-
Short	+	+	+	+	+
Degree of Subcontracting					
Heavy	0	-	-	-	-
Light	+	+	+	+	+
Contract Complexity					
Complex	-	-	-	-	-
Simple	+	+	+	+	+

The general assessments presented in Table 3.4-1 are
based upon the definition of the variables and the experience of
prior DoD programs. For the most part, the framework presents
assessments that could be deduced from careful reasoning. For
example, if significant maintenance requirements are anticipated,
an F^3 approach is not recommended. This is based upon the
internal design freedom afforded the second source. Similarly,
if the system either is pushing the state-of-the-art or is highly
complex, contractor teaming may be preferred. This is due to the
direct contractor-to-contractor involvement under a teaming
approach. In addition, a leader-follower or directed licensing
approach also may be applicable for highly complex systems, due
to direct contractor-to-contractor technical exchange.

Given these considerations, the program manager should
focus on identifying relative, but realistic, variable assessment
values based upon the particular program. The framework can
provide useful management insights, but it is limited by the
validity and rigor of the values. If the program manager
exercises sufficient care in assessing the variables, the
framework can identify critical areas for further research.

Thus, to employ the framework, the program manager must
undertake some limited preliminary analyses. These analyses may
assess the program's progress curve or rank the technical
complexity relative to prior production competition programs.
Following this, the program manager can use Table 3.4-1 to
investigate the potential for competition. If the variables

overwhelmingly favor a particular approach or approaches; those
areas should be investigated in detail, as described in Part II.
If the variables overwhelmingly indicate that competition is not
applicable, the program manager may begin to investigate other
methods to control costs, or the program manager may seek to
overcome those barriers to competition which were revealed by the
preliminary screen.

3.5   EARLY PLANNING

The results of the preliminary screen can be used to
support early program planning for production competition. This
will ensure that early activities enhance rather than preclude
future production competition. If the preliminary analysis
indicates that production competition may be promising, the
program manager should undertake the following:

- Secure unlimited data rights from the system
  developer by including a data rights clause as an
  option on the development contract.

- Assess the potential for second source interest in
  the program by conducting preliminary market
  surveys.

- Include anticipated funding requirements in the
  POM and FYDP.

- Investigate special tooling and test equipment
  requirements.

- Identify critical constraints to production
  competition.

These activities can be accomplished at little cost, while
enhancing the ability of the program manager to implement
production competition later, if the detailed analysis indicates
competition is likely to be beneficial.

PART TWO

EVALUATION OF PRODUCTION COMPETITION

4.   **ECONOMIC ANALYSIS**

        Production competition is a complex undertaking
requiring detailed economic, technical, and program analyses
based on specific program circumstances. The results of these
analyses are crucial to the successful planning and
implementation of production competition. Chapters Five and Six
present technical and program analyses. This chapter presents
the economic analysis of production competition, including the
following:

- Overview of economic analysis

- Key economic variables

- Calculation of the net present value of
  competition

- Uncertainty and sensitivity analysis

- Computer assistance

- The OSD CAIG Approach

- The OSD PESO Approach

4.1   OVERVIEW OF ECONOMIC ISSUES AND PROCESS

        To evaluate the economic effectiveness of production
competition and to differentiate between alternative competitive
strategies, the program manager must view competition as an
investment decision. The key elements of the investment equation
are reduced unit procurement costs, increased up-front costs, and
increased government administration costs. In addition, the

potential effects on logistic support costs must be considered.
This trade-off is unique for each program, being determined by
program circumstances.

This chapter presents an approach which can be used by
the program manager to perform an economic analysis of the likely
value of production competition. The approach concentrates
strictly upon program-specific features. Broader concerns, such
as a technically enhanced industrial base, overhead absorption,
and company-funded research and development are not addressed.
Those issues are economic in nature and possibly could be
quantified; however, they are associated with defense industrial
base policy and are better addressed by policy makers on a
DoD-wide level.

The economic analysis described in this chapter can be
employed by the program manager in any phase of the acquisition
cycle. The confidence that the program manager places in the
results of this analysis should be determined by the accuracy and
adequacy of the data input to the analysis. the early
development phase, the program manager may un ake this
analysis to support early planning with little emphasis placed on
budget development. As the system progress through its
development cycle, the program manager should undertake
additional analyses to refine the program plan and to support
budget submissions. Thus, the program manager should view the
economic analysis of production competition as a continuous
process, as presented in Figure 4.1-1.

EXPLORATION	VALIDATION	FSD	PRODUCTION/DEPLOYMENT
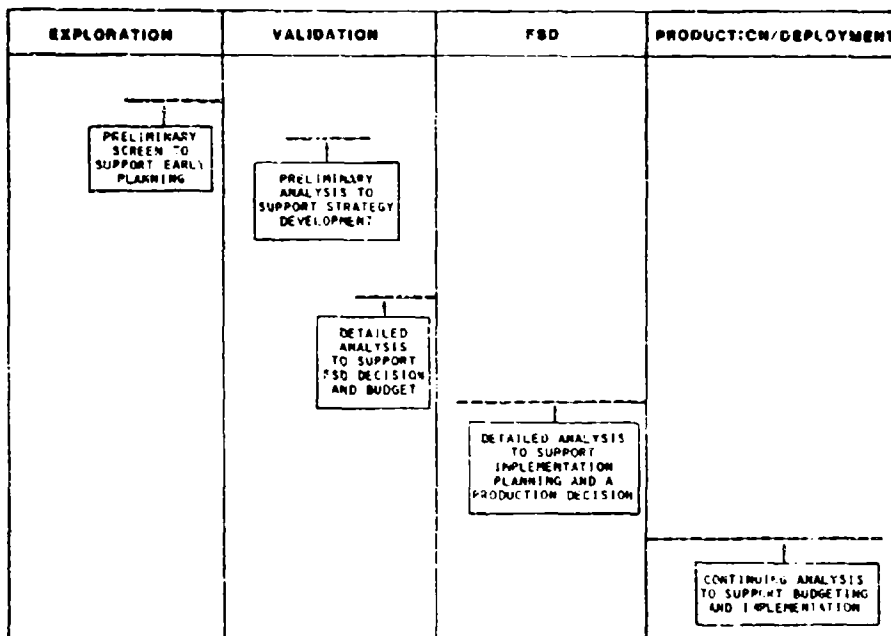
Figure 4.1-1   Economic Analysis of Production Competition

The program manager also should note that as a system advances in development, the reliability of the cost and technical data associated with the system increases. As confidence in available data increases, the economics of the production competition decision can be reviewed in several ways. Two ways of assessing production competition are presented; the net present value approach and the OSD approach, following a detailed discussion of the key economic variables.

4.2   KEY ECONOMIC VARIABLES

Numerous costs and benefits have been attributed to production competition. This chapter will concentrate on those variables that directly influence a program manager's assessment

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of production competition, including the following:

- Nonrecurring cost

- Single source recurring production costs

- Original source recurring production costs

- Second source recurring production costs

- The effect of production rate on unit production cost

- Government administrative costs

- Logistic support costs

- The use of a discount rate

Nonrecurring Costs

Certain nonrecurring costs are associated with the establishment of production competition. Because they are incurred early in the program, it is important that these costs be reviewed and estimated with care. The nonrecurring cost elements associated with production competition include the following:

- Contractor research and development

- Technology transfer

- Production qualification of the second source and its suppliers

- Additional capital equipment, test equipment, and tooling

- Government and contractor management

- Facilities costs (if applicable)

Contractor research and development costs refer to the costs associated with efforts undertaken by the second source to

translate and utilize the design specifications. This may require reverse engineering of selected components. In addition, research and development efforts may be undertaken to redesign components or subsystems which the developer has claimed as proprietary.

The program manager should note that different technology transfer techniques may have different contractor research and development costs. For example, a form, fit, and function (F^3) technique may require a substantial amount of contractor development. Similarly, a technical data package (TDP) technique may require reverse engineering. In contrast, a leader-follower approach should not require as high a level of contractor development as the other two techniques.

The technology transfer costs are determined by the competitive production technique which is employed. In the case of a TDP technique, these costs include developer preparation and government qualification of the TDP. In the case of a leader-follower technique, these costs include the cost of the leader's assistance to the follower. Under a licensing agreement, a royalty may be involved.

The costs associated with production qualification of the second source and related suppliers also must be estimated. These costs include the cost of items fabricated by the second source for qualification and the cost of government test facilities and personnel.

Additional capital equipment, test equipment, and tooling costs must be calculated also. It is often assumed that these costs are twice the capital costs of a single source approach. This assumption may be useful for early assessments; however, it ignores the effect of rational production planning.

An estimate of capital costs should reflect the existence of two production lines, each one smaller than that established under a single source approach. Thus, if procurement quantities of 1,000 units per year are anticipated, a single manufacturer would tool a line to be efficient at 1,000 units per year. If two manufacturers are producing the same 1,000 units per year, they should tool their lines at less than 1,000 units, perhaps 700 units per year.

In addition, the capital equipment dedicated to a program by a particular contractor includes general purpose equipment which the second source may already have on-line. If the equipment must be procured, the contracting office will need to determine which costs, if any, are allowable for reimbursement.

Specialized test equipment is the key cost element in the capital equipment category. For complex systems, quality control requires that the developer and the second source use identical test equipment. This establishes a requirement for duplicative sets of test equipment down to the lowest level.

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Fortunately, this cost is also the easiest to estimate, since the developer's test equipment is priced in the development contract.

Government and contractor management costs reflect the additional government or developer administration associated with solicitation, selection, and award of the second source contract. Incremental program office personnel costs incurred during learning and directed buys are included in this category.

These nonrecurring cost elements may appear to be clearly defined and distinguishable from one another. In reality, the costs are often ill-defined, highly aggregated, and difficult to estimate. For instance, the second source may be awarded a single contract to produce several items for qualification. Included in that contract price are costs associated with research and development, fabrication, and qualification. Of course, delineation of the specific cost elements is unnecessary in a particular case as long as all cost elements are reflected in the estimate.

Table 4.2-1 presents a matrix to assist the program manager in tabulating nonrecurring costs. The table includes fiscal year spreads in order to enhance budgeting and discounting.

TABLE 4.2-1
NONRECURRING COSTS

Cost Element	Fiscal Year			Total
	FYXX	FYXY	FYXZ	
Contractor R&D				
Technology Transfer				
Qualification of Second Production Source				
Capital Equipment and Tooling				
Special Test Equipment				
Government & Contractor Management				
Total				

Single Source Recurring Production Costs

Recurring production costs for defense weapon systems
are estimated in a variety of ways. One common estimating
technique is the progress curve. A progress curve represents the
percent reduction in unit cost or price as a result of some

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percent increase in production quantities.[1] The convention
used is to indicate what percent reduction in unit cost would
occur based on a doubling of production quantity. For example,
if production unit number 1,000 of a missile program costs
$500,000 and the progress curve is 80 percent, one would predict
unit number 2,000 to cost 80 percent of $500,000 or $400,000. A
typical progress curve is shown in Figure 4.2-1.
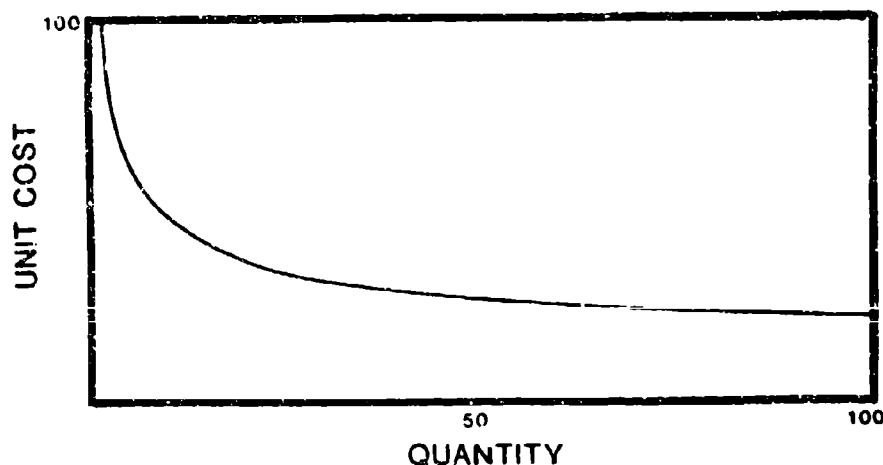
Figure 4.2-1   Progress Curve

Different authors use different terms, sometimes
interchangeably, when discussing progress curves. Often used
terms include "cost improvement curve," "learning curve," and
"experience curve". The term "progress curve" is used in this
handbook to distinguish it from the learning curve. The latter
implies reductions in labor hours due to worker learning. The

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[1]The concept of a learning curve was formulated by
T. P. Wright in 1936, based upon the manufacturing labor hours of
airframes. Since this early development, the concept has been
expanded by several authors to include price-quantity
relationships. See for example, "Perspectives on Experience,"
Boston Consulting Group, 1968.

progress curve includes all recurring costs, amortized capital cost, overhead, and profit. Thus, the progress curve presents the unit cost to the government (or contractor price). This distinction is crit cally important with respect to the competition analysis. Prior studies of production competition have documented changes in contractor price behavior due to competition, but they have not analyzed labor or production behavior changes under competition. Therefore, the learning curve concept is too narrow to use in the analysis. A detailed discussion of progress curves is presented in Appendix D.

Single source recurring production costs can be estimated directly from the unit cost progress curve.[2] Typically, these costs will be estimated by comptroller or program office personnel and used as the program baseline. The unit cost progress curve formulation is given by equation 4.2-1.

$$Z = A \cdot X^B \qquad (4.2-1)$$

Where:

    Z = unit cost of the item number X
    A = first unit cost
    X = cumulative quantity produced
    B = exponent which describes the slope
        of the progress curve, defined
        as the ln (progress rate)/ln(2)

The single source cost could be estimated by summing up all individual unit costs associated with a given production run; however, this process would e laborious and time consuming.

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[2] The unit cost formulation is used in assessing production competition because it reveals changing cost behavior more readily than the cumulative cost formulation. For a more detailed discussion, see Appendix D and: Lou Kratz and Larry Cox, "Analysis of AMRAAM Acquisition Alternatives: Phase II," The Analytic Sciences Corporation, May 1982.

Fortunately, the program manager can simplify the computations by
noting that the progress curve is a continuous function. Thus,
the area under the curve is the total cost for a given number of
units produced, as illustrated by Figure 4.2-2.
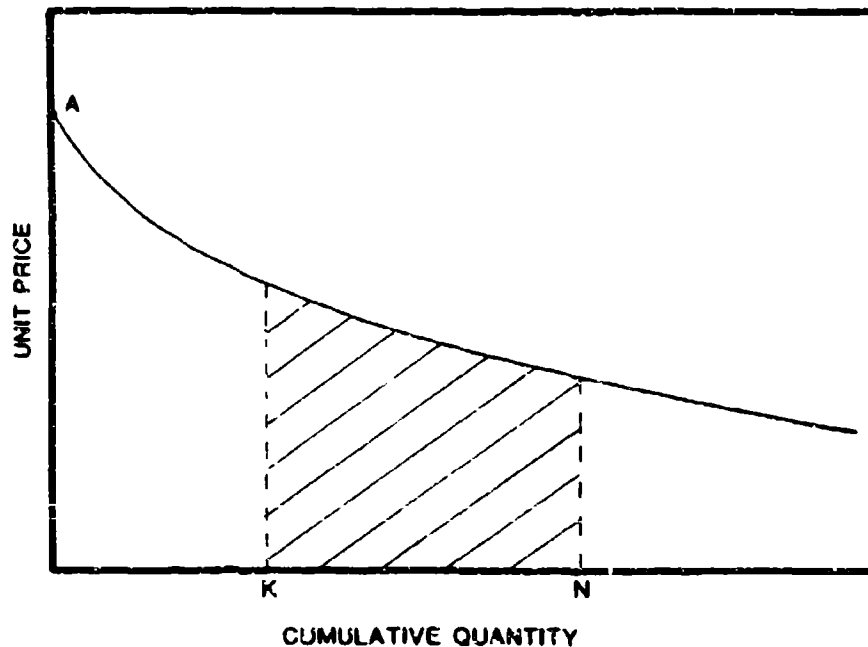
Figure 4.2-2   Single Source Recurring Production Costs

As the number of units produced increases, the unit
cost declines, based upon the progress curve formulation. The
unit cost curve is derived from equation 4.2-1, using the
progress curve exponent, B. The curve crosses the vertical axis
at point A, the first unit cost. The total cost of producing
N-K+1 units is the shaded area, which shows the cost curve from
unit K through unit N.

Using this approach, the total cost may be found by
using integral calculus to estimate the shaded area, as shown in
equation 4.2-2.

$$C(K,N) = \frac{A}{B+1} \left[N^{B+1} - K^{B+1} \right] \qquad (4.2\text{-}2)$$

where: $C(K,N)$ = the cost of producing all units
from K through N. Thus, the total
units produced in a lot = N − K + 1.

A = first unit cost

B = ln(progress rate)/ln(2)

One should note that the form of equation 4.2-2 is different than 4.2-1 in several important ways. The intercept term, A, is now divided by one plus the progress rate, 1 + B. Also, the exponent is 1 plus the progress rate, 1 + B, instead of just B. These changes come about through integration of equation 4.2-1 (i.e., application of a technique in integral calculus). The form of the equation represents the total cost of producing N − K + 1 units. If one used equation 4.2-1 directly, it would be necessary to calculate the cost of each unit, then sum the total costs. Equation 4.2-2 allows immediate calculation of a very close approximation of total costs.

To illustrate equation 4.2-2, assume that first unit cost is $10,000 and the progress rate is 90 percent. The cost of the third production lot, which begins at unit 155 (K=155) and continues to unit 210 (N=210), would be estimated as shown in equation 4.2-3. The value B + 1 equals 0.848.

$$C(155,210) = \frac{\$10,000}{.848}\left[210^{.848} - 155^{.848}\right] \qquad (4.2-3)$$

Total Recurring Lot Cost = $249,425

A total of 56 units are produced (N-K + 1 = 56) at an average price of $4,454. The substantial decline in price from the first unit price of $10,000 is due to the progress function.

Original Source Recurring Production Costs

Competitive recurring production costs also are estimated using progress curves; however, changes to the progress curve are introduced to reflect contractor price behavior in a competitive environment. Furthermore, costs must be estimated for two contractors, the developer and the second source.

Prior empirical studies have indicated that continuous production competition leads to changes in the price behavior of the original producer. These studies suggest that when competition is introduced into a previously single source program, the original producer may offer an immediate price reduction. This is shown as a downward shift of the producer's progress curve. Furthermore, the empirical research indicates that the original producer, faced with annual recompetitions, continues to offer price reductions at a faster rate than would be expected from the previously demonstrated progress curve. These reductions are shown as a rotation of the original

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produc r's progress curve. Given this behavior, the costs of the original source's production can be presented as shown in Figure 4.2-3.
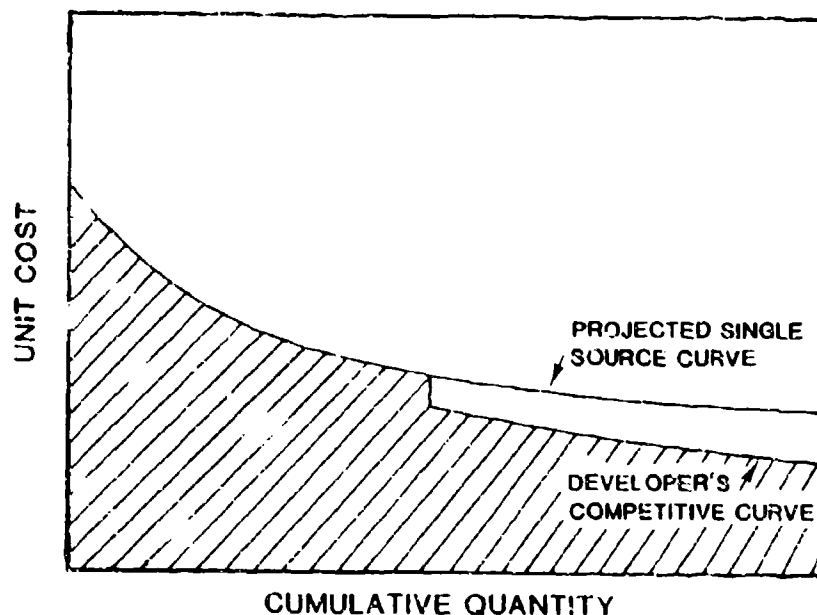
Figure 4.2-3   Original Source Recurring Production Costs

Based upon equation 4.2-2. the original producer's costs can be estimated by integrating the original progress curve and the competitive curve. This is shown in Equation 4.2-4.

$$C_O = \frac{A}{B+1} \left[N^{B+1} - 1^{B+1} \right] + \frac{A'}{B'+1} \left[M^{B'+1} - (N+1)^{B'+1} \right] \quad (4.2-4)$$

where:

   C_O = total recurring cost of the original producer

   A,A' = single source and (implied) competitive
           first unit costs

   B,B' = single source and competitive progress rate

   N,M = last units produced sole source and
          competitively

   $N,M-N$ = total units produced by the original producer
            both single source and competitively

The first half of equation 4.2-4 represents the total
cost of production during the sole source phase. The parameters
A and B and the production quantity N determine those costs. The
second half of the equation calculates the total production costs
(for this producer) under competitive production. The parameters
A' and B' and the production quantity M - N determine the
competitive costs.

The program manager must recognize that the magnitude
of the potential shift and rotation is dependent upon program
circumstances, including the following:

- Intensity of the competition - If the original
  producer perceives that the second source cannot
  be competitive, perhaps due to inadequate
  technology transfer, the original producer is less
  likely to offer price reductions.

- Timing of the competition - If the competition is
  held early in the production cycle when
  producibility risks still remain, the original
  producer will be less willing to offer large price
  reductions.

- Ability of the original producer to reduce costs -
  If the system was competitively developed and the
  original producer has demonstrated adequate cost
  control, the contractor may not be capable of
  further price reductions. Conversely, if the
  original developer has experienced significant
  cost growth, competition may lead to greater
  control and large cost reductions.

- System and manufacturing technology - If the
  manufacture of the system requires complex
  processes and equipment, the original producer may
  be unable to offer large price reductions.

The shifts and rotations observed by one author on prior tactical missile programs are shown in Table 4.2-2.[3] The large variance in observed shift and rotation should convince the program manager that the use of average values is inappropriate and that program circumstances must be considered. The programs shown in Table 4.2-2 involved different contractors and different technology transfer techniques. Furthermore, competition was introduced at different points in the production phase for each program. The table is an example of the empirical research that indicates the need for program-specific analysis to determine the shift and rotation parameters appropriate to the analysis at hand. The program manager is cautioned not to accept simplistic averages. It is suggested that the program manager assume some reasonable set of parameters that adequately reflects program circumstances, then conduct sensitivity analyses.

It should be recognized that the cost base to which competition savings apply is not necessarily the total cost. There may be vendor and lower tier costs which would not be changed substantially by the use of competition at the prime contractor level. If, for example, the vendors were already producing at competitive rates because of other programs, there could be few gains from additional competition. The program manager should determine, within reasonable bounds of estimation, what the appropriate cost base is for competition analysis.

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[3]Larry W. Cox and Jacques S. Gansler, "Evaluating the Impact of Quantity, Rate, and Competition," CONCEPTS, The Journal of Defense Systems Acquisition Management, Volume 4, Number 4, Autumn 1981.

In relation to this point, it may be argued that wherever prime contractors have a common vendor or supplier, that cost should not be considered as having a potential competitive cost reduction. However, that argument overlooks the overhead and fee which can be loaded onto the item's price and which can be reduced for competitive advantage.

TABLE 4.2-2
OBSERVED SHIFTS AND ROTATION

Program	Contractor	Shift (%) (Downward)	Rotation (%) (Steepening)
SPARROW	Raytheon	4	8
BULLPUP	Martin	14	13
TOW	Hughes	15	32
AIM-9B	General Electric	9	6
AIM-9C	Raytheon	10	7

Second Source Recurring Production Cost

Costs for the second producer must be estimated also. The undetermined issue is the second source progress rate and first unit cost. Limited research has been performed in the area of second source cost behavior. Recent studies indicate that the second source may demonstrate a lower first unit cost and steeper progress curve than initially demonstrated by the developer. The

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results of one of these studies are presented in Table 4.2-3.[4]

TABLE 4.2-3
SECOND SOURCE BEHAVIOR

| Program | Progress Rate | | Difference % | Percent First Unit Cost Reduction |
	First Source	Second Source		
SPARROW	.87	.84	3	14
BULLPUP	.82	.80	2	46
TOW	.98	.89	9	20
AIM-9B	.90	.83	7	17
AIM-9L	.91	.87	4	18

Once again the empirical results are diverse. The reduction in first unit cost has been attributed to technology transfusion and reduced engineering burden. The possible causes of the steeper progress curves are numerous and related to the desire of the second source to become price competitive with the developer.

Due to the relationship between first unit cost reduction and technology transfusion, the program manager must

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[4]Lou Kratz and Larry Cox, et al, "Competition of Defense Procurements: Evidence, Theory, and Application," The 1982 Federal Acquisition Research Symposium, Washington, D. C. May 1982.

assess the potential for a reduction in first unit cost based
upon program characteristics. If the second source is introduced
early in the program, a reduction in first unit cost should not
be expected. If the second producer is introduced after the
system has been in production for several years, a sizeable
reduction in first unit cost may be reasonable. Similarly, the
program manager must determine a reasonable assumption concerning
the second source progress rate. In making this determination
the program manager should consider the system technology, the
manufacturing technology employed, and the potential for
manufacturing innovation. Once reasonable parameters have been
identified the second source costs can be estimated by using
equation 4.2-2.

Given the uncertainty surrounding the second source
progress curve, the program manager may desire to employ an
alternative method that avoids the many assumptions concerning
second source cost behavior. Such a method has been suggested by
the Office of the Secretary of Defense, Cost Analysis Improvement
Group (OSD CAIG). The method involves solving for the second
source cost that would ensure that the competition attains break
even. This method is discussed in Section 4.6.

Production Rate

The use of a progress curve to estimate recurring
production cost is a convenient method that is accepted

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throughout DoD. The program manager must recognize that the progress curve is limited in that it expresses unit cost strictly as a function of cumulative quantity produced and does not take into account the rate of production.[5] The rate effect on unit cost may be important in competition analyses because splitting the production run will cause each firm to produce at a rate which is lower than what the single source rate would have been.

Several simple models have been developed to express unit price as a function of cumulative quantity and production rate per period. Most of these formulations express production rate effects on unit cost in a manner similar to progress curves.[6] That is, a doubling in production rate per period leads to a constant percentage reduction in unit cost. Several of these studies are summarized in Appendix C.

Mathematically, the production rate formulation can be incorporated into the progress curve function as shown in equation 4.2-5.

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[5]R. Crouch, "Avoiding Bias in Progress Function," Defense Management Journal, Third Quarter 1980.

[6]See for example, John E. Bemis, "A Model for Examining the Cost Implications of Production Rate," CONCEPTS, The Journal of Defense Systems Acquisition Management, Volume 4, Number 2, Spring 1981.

$$Z = A \cdot X^B \cdot R^C \qquad\qquad (4.2\text{-}5)$$

where:

Z = unit cost of the item number X

A = first unit cost

X = cumulative quantity produced

B = exponent which describes the slope of the progress curve, defined as the ln (progress rate)/ln(2)

R = production rate in a particular period

C = exponent which describes the slope of the production rate curve, defined as the ln (production rate parameter)/ ln(2)

This formulation is used by several DoD components to capture the effects of production rate on unit cost.[7] The Defense Systems Management College also has sponsored research based upon this formulation.[8] The formulation is a simple method to incorporate the effects of production; however, to employ it the program manager must have some indication of what the parameter should be. The program manager may be able to arriv at such a parameter based upon should-cost studies of the system developer. Also, care should be taken when extreme changes in quantity are analyzed. For example, if the

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[7]Charles Ayers, et al, "The AFSC Production Rate Variations Model: Prototype Documentation," The Analytic Sciences Corporation, TR-4612-2-1, May 1984.

[8]Edward J. Downing, et al, "Economic Production Rate Study," The 1983 Federal Acquisition Research Symposium, Williamsburg, Virginia, December 1983.

developing contractor is tooled to produce at 1000 units per year and budget cuts cause the rate to drop to or.)0 units per year, it is possible the contractor will change some of his fixed costs. Therefore, the rate formula in its original form may well have to be modified.

Government Administrative Costs

In addition to contractor production costs, the program manager also should consider additional government management and administration costs associated with competitive production. These costs include additional personnel and facilities to conduct the solicitation, selection and award of competitive contracts, follow-on lot acceptance test, and the continuing management of two contractors. Unfortunately, these costs have not been identified for prior programs; thus, no historical data base exists.

This lack of historical data should not limit the inclusion of government personnel costs for future programs. The program manager can make reasonable assumptions concerning incremental program office personnel such as an additional technical monitor, additional cost analysts, additional engineering support, and additional contracting personnel. These personnel requirements can be translated into costs by use of standard federal pay scales. The costs should be expressed by fiscal year to facilitate discounting analyses.

Configuration management costs could be higher under competitive production and should be considered. The problem of maintaining two on-going production lines which produce possibly identical products could be substantial. However, one also might observe fewer engineering changes than under sole source production. Thus, the program manager should consider the incremental costs, schedule delays or other problems associated with competition and configuration management.

The program manager also should be aware of the effect of competition on the costs of other programs which the contractor may have. For example, if competition leads to a cut back in the firm's production quantity, the firm may reallocate fixed overhead to other programs in the plant. The costs of those programs would increase, but that cost would not be considered in the competition decision.

Logistic Support Costs

The use of production competition to reduce acquisition costs may adversely affect logistic support costs. This adverse effect would be due to the additional costs of supporting two fielded configurations. The magnitude of these costs is a function of the extent of commonality between the two producers' configurations. Two fielded configurations could adversely affect all logistic support cost elements, including the following:

- Manpower and personnel

- Supply support

- Support equipment

- Technical data

- Training

- Facilities

- Packaging, handling, storage, and transportation

The program manager could limit the potential logistics cost by requiring both producers' configurations to be compatible down to the throwaway level. This approach constrains production flexibility, thus limiting the potential for cost-reducing design changes. In addition, this severe constraint may require the use of the same subcontractors or vendors by both system contractors. Thus, production cost reductions may be further limited.

The program manager is faced with a trade-off between production flexibility and potential support cost increases. These potential increases, and thus the degree of design flexibility, are determined largely by the weapon system support concept. For example, a tactical missile supported under a "wooden round" concept may provide ample design flexibility with no increase in support cost. The missile is GO-NO-GO tested in the field. If a failure occurs, the missile is returned to the responsible contractor.

The "wooden round" example is in contrast to a missile supported under a two level maintenance concept. A missile

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failure would lead to subsystem fault isolation. If the two production contractors exercised unlimited design flexibility, the failed subsystem may not be interchangeable with one from the other producer. Thus, it would be necessary to stock spares for both configurations including subsystems, components, and parts.

Innovative approaches to the logistic support cost effects should be investigated. The use of contractor warranties may limit the initial support cost effects of two configurations. Field failures would be returned to the responsible contractor. The warranty approach has the advantage of the contractors pricing their support in a competitive environment; however, this is only an interim solution. Normally, the program manager must plan for organic support of the system.

Major programs are required to conduct logistic support and life cycle cost analyses. In regard to production competition, it is suggested that the program manager rely on the logistics cost analysts and engineers to identify the cost effect of design differences at various levels in the configuration. These personnel can employ existing life cycle cost models and the selected system support concept to identify potential cost effects. Table 4.2-4 presents a matrix to assist the program manager in tabulating potential incremental operation and support costs. The table includes fiscal year spreads to enhance budgeting and discounting.

TABLE 4.2-4
INCREMENTAL OPERATION AND SUPPORT COSTS

Cost Element	Fiscal Year							Total
	FYXT	FYXU	FYXV	FYXW	FYXX	FYXY	FYXZ	
Manpower and Personnel								
Supply Support								
Support Equipment								
Technical Data								
Training								
Facilities								
Packaging, Handling, Storage, & Transportation								
Total								

Discount Rate

The economic analysis of production competition
can be viewed as an investment decision: initial nonrecurring
investment versus future recurring returns expressed as reduced
unit production costs. This comparison is similar to a standard
return on investment analysis.

One key feature of return on investment analysis is consideration of the time value of money through the use of a discount rate. For example, one dollar invested today at an annual interest rate of ten percent is equivalent to $1.10 one year from now. Similarly, $1.10 one year from now, assuming a discount rate of ten percent is equivalent to $1.00 today.

In conducting investment decision analyses, the program manager is required by OMB Circular A-94 and DoD Instruction 7041.3 to use a ten percent discount rate on constant year dollar estimates. Application of the ten percent discount rate to the annual cost and benefits of production competition will enable the program manager to calculate the net present value of competition.

4.3   CALCULATION OF THE NET PRESENT VALUE OF COMPETITION

The economic analysis of production competition can be viewed as similar to the analysis of any other investment decision. A key tool in such analysis is the calculation of the net present value of the investment. In assessing production competition, the net present value can be calculated as shown in equation 4.3-1.

$$NPV_c = SS - (C_1 + C_2 + G) - NR - LS \qquad (4.3\text{-}1)$$

where:

NPV_c = net present value of production competition

SS = discounted projected single source recurring production costs

C_1 = discounted projected recurring production cost of the original producer in competition

C_2 = discounted projected recurring production cost of the second producer in competition

G = discounted incremental governm nt administrative cost associated with competition

NR · discounted nonrecurring costs associated with competition

LS = discounted incremental logistic support cost associated with competition

Equation 4.3-1 presents the summation of all relevant economic variables. This can be simplified as shown in equation 4.3-2.

NPV = Present value of net cost reduction –   (4.3-2)
      present value of nonrecurring costs

$$NPV = \sum \frac{CR_i}{(i+r)^i} - \sum \frac{NR_i + LS_i}{(i+r)^i}$$

where: NPV = net present value of competition
             investment

       CR = net cost reductions due to competitive
            production in year i (stated in
            constant dollars)

       NR = nonrecurring costs incurred due to
            competitive production in year i
            (stated in constant dollars)

       LS = incremental logistics costs

        r = discount rate, set at .10

The application in equation 4.3-1 yields the discounted net present value of production competition for a particular program. The use of this value is demonstrated using an example presented in Appendix E.

To employ equation 4.3-2 the program manager must sum all the relevant cost elements and potential cost reductions. This approach would involve nine steps, similar to the following:

(1) Estimate single source recurring production costs
     by fiscal year in constant dollars based upon
     progress curves and expressed as contractor price.

(2) Estimate competitive recurring production costs by
     fiscal year in constant dollars based upon
     progress curves. Reasonable assumptions must be
     made concerning shift and rotation and the second
     source progress curve.

(3) Calculate potential savings by subtracting (2)
     from (1) by fiscal year.

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(4)　Calculate net potential savings by subtracting annual incremental government cost, stated in constant dollars, from (3).

(5)　Estimate nonrecurring startup costs, stated in constant dollars, by fiscal year.

(6)　Estimate incremental logistic support costs, stated in constant dollars, by fiscal year.

(7)　Calculate the net present value of competitive versus sole source production costs by subtracting the discounted costs (5) and (6) from the discounted benefits (3).

(8)　Compare discounted, constant, and then-year dollar estimates of single source and competitive production.

(9)　Conduct detailed sensitivity analyses to investigate the effect of changes in key assumptions on the estimate of savings, and to develop a range of likely estimates.

The program manager should note that the above analysis can be used to support the budget process. The fiscal year estimates, in constant dollars, can be escalated in accordance with current inflation indices to estimate future annual funding requirements.

4.4　UNCERTAINTY AND SENSITIVITY ANALYSIS

In the early phases of the program, the economic variables may not be well defined. Thus, there may be uncertainty associated with the values that must be assumed in order to conduct the economic analysis. As the system becomes better defined, this uncertainty can be reduced. For example, the program manager could solicit producibility studies from potential second sources. These studies could be used to identify reasonable second source progress curve parameters. Similarly, prepriced options or price discounts offered by the

original source could be used as reasonable shift and rotation measures. In addition, the program manager should employ relevant historical data, whenever possible.

These steps decrease uncertainty; however, because the economic analysis is performed based upon potential outcomes, uncertainty cannot be eliminated. The key to the basic analysis is to effectively employ available data. The uncertainty associated with the analysis then can be addressed through sensitivity analysis. In performing economic analysis of production competition, sensitivity analysis can be used to identify key assumptions that significantly affect the competition decision. In addition, sensitivity analyses can be used to establish reasonable bounds around the cost estimates.

The assumptions made concerning the values of the economic variables will have uncertainty associated with them. This is especially true of analyses undertaken early in a program. Sensitivity analysis can be used to identify the critical assumptions. If an assumption has a high uncertainty, but the variable does not significantly influence the outcome of the economic analysis, then the uncertainty is not critical. Conversely, if sensitivity analysis indicates that a variable has a large effect on the outcome, the program manager should concentrate on arriving at the best possible estimate of that variable.

Sensitivity analysis also can be used to establish reasonable cost estimate bounds. Given the uncertainty associated with the analysis, the program manager may wish to portray the cost estimates as ranges rather than as a point estimate. This approach is useful early in a program in that it enables management decisions to be made based upon ranges of estimates rather than a single point estimate.

In performing economic analyses of production competition, the program manager should conduct sensitivity analysis on the following variables:

- Total planned quantity
- Progress curves
- Shift and rotation
- Timing of competition

Anticipated production quantities for a new program are established by operational requirements. Often, anticipated quantities are not realized, due to a changing threat, revised inventory requirements, or budget constraints. On the other hand, potential foreign military sales may extend the production run. The high initial investment associated with production competition dictates that the program manager investigate the effect of changes in total production quantities on the production competition decision.

Uncertainty also is associated with the projected progress curve. Prior to production, the progress curves for

weapon systems are estimated based upon DoD experience with similar systems and contractor data. Prior empirical studies have demonstrated that, under competition, greater recurring cost savings are associated with flatter initial progress rates. Therefore, the sensitivity of the competition decision to changes in the projected progress curve should be investigated.

Similarly, the sensitivity of the production competition decision to the assumed second source progress curve rate must be investigated. The empirical evidence indicates a wide variation in steepness for tactical missiles. In addition, this steeper curve is taken as an assumption, rather than being estimated from prior data. Therefore, sensitivity analysis is particularly important.

Sensitivity analyses also must be conducted on the shift and rotation parameters due to the dispersion and limitations of the historical data. The greater the assumed shift or rotation, the greater would be the potential savings. More detailed analysis is necessary to identify the minimum shift and rotation necessary to balance the costs of establishing the competitive source. If the required break-even shift and rotation parameters are beyond the historically observed range, production competition may not be economically beneficial. If potential savings are projected even when using conservative assumptions, production competition may be promising.

The timing of the first competitive award is a critical
decision variable for any production competition program due to
its direct relationship to the following:

- The selection of a technology transfer method
- Break-even analysis

Prior analyses have established that greater potential savings
can be attained by initiating competitive awards earlier in the
production program. The ability of the program manager to
conduct early competitive awards is largely a function of the
technique used to effect technology transfer. For example, a TDP
strategy may enable competitive awards to begin in the fourth
year of production. By initiating technology transfer during
FSD, through teaming or a leader-follower strategy, the program
manager may be able to achieve competitive production awards in
the second or third year of production.

Early competitive awards may be difficult to achieve,
since early second source involvement may be precluded by
constrained near-term funding. In such a situation, the program
manager must identify the break-even point. If second source
development and competitive production must be delayed, the point
at which competition is no longer economically viable should be
identified. For example, if effective technology transfer cannot
be achieved until the fifth year of an eight year production
program, competition may not be economically attractive.

4.5   COMPUTER ASSISTANCE

The economic analysis of production competition
requires extensive consideration of all relevant variables.
Fortunately, several computer-based models currently exist to
assist the program manager in performing the necessary
calculations. These models incorporate the analytic framework
discussed in this chapter and are available from internal
government organizations as well as from independent contractors.
One model that currently resides in an internal government
organization is the Competition Decision-Assist Package (CDAP).

The Army Procurement Research Office (APRO) has
developed a computer based model to assist program managers in
performing economic analysis of production competition.[9] The
CDAP builds upon the basic framework presented in Section 4.3.
In addition, CDAP incorporates parameter bounds and simulation to
enhance sensitivity analysis. Cost estimates can be presented as
a range based upon the parameter ranges that are input by the
program manager. The program manager should note that this
requires that probability distributions for the parameters, as
well as parameter values, be input to the model.

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[9]Charles H. Smith, "Production Rate and Weapons
System Cost: Research Review Case Studies and Planning Model,"
U.S. Army Procurement Research Office, Report No. APRO-80-05,
November 1980.

4.6   THE OSD CAIG APPROACH

The OSD Cost Analysis Improvement Group (CAIG) recently has developed a quantitative approach to the analysis of competition.[10] The approach is intended to overcome some of the problems associated with the net present value method, in that it requires fewer assumptions by the program manager. Although the CAIG approach has yet to be widely published, it appears to offer a reasonable approach to the production competition decision.

The starting point of the CAIG methodology is different than in the net present value method. The question it addresses is the following: what are the additional costs which would be imposed on the program office by the implementation of competition? An accurate estimate of those costs would then tell the program manager what savings would have to be obtained by competition in order to be cost effective. The goal is to determine the cost at which the new competitor must produce in order to break even. This cost can be compared to the cost of the single source contractor and be characterized as reasonable, unreasonable, or marginally reasonable. The program manager then can combine this information with the other nonquantifiable

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[10]Raymond G. Bonesteele and James L. Wilson, "A Method for Analyzing Competitive Dual Source Production Programs," OSD CAIG, unpublished paper, May 1984.

benefits and penalties which arise as a result of competition to make a final decision on proceeding with production competition.

If the CAIG approach results in a decision to proceed with production competition, it will be necessary for the program manager to perform a net present value analysis (previously described in this chapter) in order to develop funding requirements to use in the POM/budgeting process.

4.7   THE OSD PESO APPROACH

The OSD Product Engineering Service Office (PESO) has developed and applied extensively an approach similar to that presented in Section 4.2. The approach has been documented by Bemis.[11]

The PESO method is similar to the net present value method discussed in Section 4.3; thus, it will not be discussed in detail. As in most of the competition models, it uses a shift and rotation progress curve formulation with a rate adjustment factor. Ranges of estimates are obtained using sensitivity analysis on key factors. In following the net present value method discussed in Section 4.3, the program manager will obtain

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[11]John C. Bemis, "A Model for Examining the Cost Implications of Production Rate," CONCEPTS, The Journal of Defense Systems Acquisition Management, Volume 4, Number 2, Spring 1981.

results similar to those that would be obtained from the OSD PESO
method, if similar parameter assumptions are made.

4.8   SUMMARY OF ECONOMIC ANALYSIS

This chapter has presented the economic analysis that
must be undertaken by the program manager in assessing production
competition.   This analysis can be summarized as follows:

(1)   Estimate single source recurring production costs
      by fiscal year in constant dollars based upon
      progress curves and expressed as contractor price.

(2)   Estimate competitive recurring production costs by
      fiscal year in constant dollars based upon
      progress curves. Reasonable assumptions must be
      made concerning shift and rotation and the second
      source progress curve.

(3)   Calculate potential savings by subtracting (2)
      from (1) by fiscal year.

(4)   Calculate net potential savings by subtracting
      annual incremental government cost, stated in
      constant dollars, from (3).

(5)   Estimate nonrecurring start-up costs, stated in
      constant dollars, by fiscal year.

(6)   Estimate incremental logistic support costs,
      stated in constant dollars, by fiscal year.

(7)   Calculate the net present value of competitive
      versus sole source production costs by subtracting
      the discounted costs (5) and (6) from the
      discounted benefits (3).

(8)   Compare discounted, constant, and then year dollar
      estimates of single source and competitive
      production.

(9)   Conduct detailed sensitivity analyses to
      investigate the effect of changes in key
      assumptions on the estimate of savings, and to
      develop a range of likely estimates.

Chapter Five presents the technical issues associated with production competition that must be assessed by the program manager.

5.   TECHNICAL ANALYSIS

A program manager developing a strategy for introducing production competition must take into account the level and type f technology inherent in the system's design and manufacturing process. The system's technological characteristics should influence the method of technology transfer, the economic analysis, source selection planning, and the program schedule.

Analysis of the system's technology involves the following issues:

- Level and type of required technology

- Availability of alternative development and production sources

- Status of the technical data package

- Potential for technological innovation in design and manufacturing

- Plans for future development.

- Proprietary data

This chapter examines these issues in terms of their influence on production competition planning.[1]

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[1] Much of the information in this chapter was developed in an acquisition strategy analysis performed in 1981 by K. E. Lanham and J. W. Drinnon (then at Putnam, Hayes & Bartlett, Inc.) for the Joint Cruise Missiles Project.

5.1   LEVEL OF TECHNOLOGY

The level and type of technology inherent in a weapon system's design should influence the program manager's choice of technology transfer technique. For example, a technical data package (TDP) approach to establishing a competitive production source for a complex surface-to-surface missile would require the recipient of the TDP to have some in-house engineering capability, the quality of the TDP determining the degree of engineering expertise required. A leader-follower program would probably demand somewhat less engineering expertise resident in the second source, compared to a TDP approach.

On the other hand, a form, fit, and function (F^3) program would require a much higher level of technological skill in the second source. The second source, to be competitive, would be required to undertake significant design and manufacturing efforts in a relatively short time, at minimal development cost. A contractor teaming arrangement could serve to meld the specialized technological skills of contractors individually lacking the broad capabilities required in a complex program.

The program manager must consider the system's technology level when performing the economic analysis of the second-sourcing alternative. First, the technology level will influence the program's nonrecurring costs (TDP preparation, technology transfer, capital equipment, special tooling, and

special test equipment costs). Second, the technology level will
add uncertainty to estimates of the effect of competition on
recurring costs. For example, in the case of a complex system,
would the second source be expected to make great improvements in
the first source's progress curve? Or would such a program
likely lead to a second source curve that is flatter than that
obtained by the first source? The program manager can reflect
this uncertainty in the economic analysis by widening the bounds
of the sensitivity analysis.

Similarly, because of the possibility that the second
source may experience significant delays in production
qualification, the program manager must consider the system's
technology level when assessing competition in relation to
programmatic and technical issues.

5.2   AVAILABILITY OF SOURCES

The program manager must consider technological factors
when investigating source availability. The source availability
analysis involves the following:

- The availability of sources capable of performing
  as system integrator

- The availability of competitive vendors at the
  subsystem level

Program managers of prior competitive programs have been
successful in identifying qualified major contractors ready to
perform system integration and component manufacturing tasks.

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Able contractors make themselves known to the projects. For example, one of the ALCM FSD prime contractors identified more than a dozen firms which had demonstrated interest in an ALCM second source program. Years later, at least four of those firms were actively seeking the system integrator role in the TOMAHAWK program, creating an intensely competitive environment for choosing a second source. At least two of the firms seeking to become the second production source for TOMAHAWK possessed all the required technological capabilities, including the ability to perform large-scale electron-beam welding.

Similarly, past program managers have been able to identify second and third tier vendors who could offer hardware at competitive prices, either to the second prime or directly to the government in a break out program. While it is unusual for a program to experience difficulty in identifying potential lower tier second sources, difficulties do arise. Prior program managers have been able to accommodate their production competition programs to those problems, using special agreements to ensure that the second prime has access to the sole supplier of the problem component.

5.3   STATUS OF THE TECHNICAL DATA PACKAGE

The status of the technical data package is critical to the success of a competitive production program implemented through the TDP approach. In developing a strategy for using the TDP approach, and in estimating its costs in the economic

analysis, the primary consideration is the date by which a
validated produc on quality TDP will be available. Normally,
the government validates a TDP only after the first source
delivers production units (built from the TDP) and tests those
units.

Achieving competition earlier than normal in a TDP
approach can be accomplished by having potential contractors bid
on a frozen, unvalidated TDP, with source selection made on the
basis of the bid. Engineering change orders would be sent to the
second source by the program office, with each change requiring
contract modification. Finally, when the validated TDP is
available, the second source would build the system on the basis
of the new drawings.

By bidding a system on an unvalidated TDP, production
competition can be established several months earlier than
otherwise possible. Introducing competition earlier provides the
program manager with an opportunity to compete more units, but
such a procedure has the following disadvantages:

- An incomplete data package could result in a
  considerable number of contract modifications.

- The first source could delay providing the
  validated TDP, thus delaying the competition.
  This delay could damage the second source
  financially, leading to a complicated claims
  situation.

For these reasons, use of an accelerated TDP method is
very risky and rarely, if ever, justified.

Leader-follower and directed licensing techniques do not require government-validated TDPs, which suggests that these techniques should lead to a significant reduction in the lead time for achieving production competition. On the other hand, these techniques require considerable cooperation on the part of the initial source throughout technology transfer and production qualification.

An F^3 program does not require a TDP; however, to maintain appropriate commonality with the existing system design, a current TDP often is provided to the second source as a baseline. In a contractor teaming program, the TDP is the joint responsibility of the two team members, so intercompany TDP problems do not arise.

5.4 POTENTIAL FOR TECHNOLOGICAL INNOVATION

A program's acquisition strategy up to the point of production largely determines its potential for cost-reducing technological innovations. If the system reaching production is the result of a competitive development process in which cost was a major source selection criterion, there may be little opportunity for cost-effective design changes.

Manufacturing methods are determined by the system's functional specifications, which flow from mission needs and operational requirements. For example, TOMAHAWK's design requirements dictated a manufacturing technology stressing close-

tolerance machining, electron-beam welding, extensive internal machining, and use of forgings and castings. Prior to selection of a production competition technique for TOMAHAWK, a review of the system's manufacturing processes led to the conclusion that the program offered little opportunity for cost-reducing changes in manufacturing technologies, unless an F^3 technique was adopted.

Competitive production programs achieve their cost savings not from funding a second source to redesign an existing system or to develop new manufacturing technologies, but rather from the competitive pressures on two sources building the existing design. However, if the program manager believes that the system is particularly susceptible to cost-reducing technological innovations, it would be justifiable to reflect that judgment in the economic analysis. This could be reflected by forecasting a steeper-than-usual progress curve in the competitive phase of production. If the program manager's judgment is correct, the steeper curve will be the result of contractor investment in cost-effective technological innovations.

5.5 PLANS FOR FUTURE DEVELOPMENT

In developing a production competition strategy, the program manager must review future developments planned for the system. For example, consider the programmatic implications of a requirement to incorporate a new warhead or guidance system in a

future variant of a current missile. These prospective
development efforts would suggest the following:

- Establishing a second source with design
  engineering capabilities would permit competitive
  development of the required changes, with possible
  cost, schedule, and technical advantages. This
  consideration should be reflected in the program's
  source selection planning.

- An early production buy out would probably be
  unwise, if it occurred prior to the redesign
  effort.

Thus, the system's planned future development efforts must be
reflected in the program manager's analysis of and planning for
production competition.

5.6   PROPRIETARY DATA

With technologically sophisticated weapon systems, a
program manager initiating production competition can expect to
encounter problems involving proprietary data. These problems
will usually relate to the system's design, but problems with
proprietary manufacturing processes are not uncommon.

It is important, in planning a competitive production
program, that all proprietary data and processes be identified
early in the system's development cycle. The program manager
should keep in mind that contractors are more willing to resolve
proprietary data issues in a competitive environment than they
are after competitors have been eliminated. This observation has
some practical applicability. For example, it should motivate
the program manager to obtain proprietary data agreements from

all offerers when selecting the leader in a leader-follower
program.

5.7   SUMMARY OF TECHNICAL ANALYSIS

A program's technical content directly influences the
economic and programmatic analyses of production competition.
Thus, in assessing production competition, the program manager
should incorporate the technical aspects of the program into the
analyses. Specifically, the program manager should undertake the
following:

- Assess the relative attractiveness of the
  technology transfer techniques in relation to the
  level and type of technology involved.

- Incorporate the technology aspects of the program
  into the source availability analysis.

- Inv   igate the potential for design or
  man   cturing innovation.

- Incorporate the potential for follow-on
  develop nt efforts into the production
  competi ion strategy.

- Ensure that proprietary data embedded in the
  system design has been identified and priced.

6. PROGRAM ANALYSIS

Production competition is a complex undertaking that influences every aspect of the program. Thus, in addition to economic and technical analyses, the program manager must assess the attractiveness of production competition in relation to key program variables. Specifically, the program manager should analyze the potential for production competition with respect to the following:

- Program funding
- Program development schedule and risk
- Production lead times
- Degree of subcontracting
- Lower tiers
- Contracting and legal issues
- Program management complexity

Assessment of these critical areas can assist the program manager in analyzing the production competition issue and in selecting a preferred technology transfer method. Furthermore, the results of these analyses could highlight key areas of concern relative to the implementation of production competition.

6.1 PROGRAM FUNDING

The up-front, nonrecurring costs associated with production competition are a key element of the economic analysis. In addition to considering these costs as an

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investment, the program manager must assess the program's ability to provide the necessary sustained funding of the nonrecurring costs, which may be incurred over several years. This issue could be a major determinant in the competition decision, for a projected high return on investment is meaningless if the program cannot obtain the necessary up-front funding.

The up-front, nonrecurring costs associated with production competition place early pressure on a program budget. On prior tactical missile programs, those costs ranged from $20 million to over $100 million.[1] The program manager must defend this additional funding based upon the promise of reduced procurement costs five, six, or ten years later.

OSD's recognition of the importance of this early funding is evidenced by the Deputy Secretary of Defense Memorandum on Programming and Investing in Competition, of 12 March 1984. The memorandum restates DoD's commitment to increasing effective production competition, recognizing that initial investments must be undertaken. The memorandum requests the Services to identify those funds that would be required to initiate production competition on programs that offer substantial benefits. In turn, OSD pledged its support of these funds during the budget process.

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[1]Larry Cox and Michal Bohn, "An Acquisition Strategy Comparison Model," The Analytic Sciences Corporation, May 1982.

The program manager can enhance approval of funding through early planning and careful cost estimation. Once an acquisition strategy is developed, the program manager must obtain the support of appropriate command and headquarters personnel. The funding required to implement the strategy must be identified and understood. Currently, lead times between program request and release of funds span several years.[2] Thus, early identification of required funding in the Program Objective Memorandum and Five Year Defense Plan is crucial.

Funding limitations in the near years may preclude the establishment of a second production source. In such a situation, the program manager should investigate the procurement of data rights in order to preserve an option for effecting production competition later. Also, subsystem break out and other alternatives to end item competition should be considered.

Stable program budgets are critically important during the competitive production phase. Budget reductions may result in annual procurement quantities being reduced to a level that is insufficient to support two contractors. This risk is particularly troublesome in competitive programs involving major subsystems. Reductions in the annual procurement of host platforms have a cascading effect, leading to reductions in the subsystem procurement. When assessing production competition,

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[2]D. D. Knittle and R. F. Williams, "Acquisition Strategy Development," U.S. Army Procurement Research Office, February 1981.

the program manager must investigate the probable stability of the production program. Understanding the priority ranking of the program and its advocacy base throughout DoD can provide the program manager with useful insight in this area.

6.2   PROGRAM DEVELOPMENT SCHEDULE AND RISK

Economic analyses have indicated that savings arising from production competition can be increased by early second source involvement and early competitive awards. Furthermore, the early introduction of a second source presents the program manager with an opportunity to reduce technical, schedule, and cost risk, provided that the program manager employs the second source effectively. Ineffective or inappropriate introduction of a second production source into a complex development program may increase technical risk. If realized, these risks could result in higher development costs or an extended development schedule.

Modern weapon systems often are developed under conditions of extreme schedule urgency due to operational requirements or projected threats. Typically, these systems also push state-of-the-art technologies and involve considerable technical risks. Under these conditions, the urgency of the development effort may limit the ability of the program office and the contractor to develop a second source during the development phase. The forced introduction of a second supplier in such a case may increase program risk by straining program

office and contractor personnel resources. Furthermore, introduction of a second source during a compressed development effort may result in inadequate technology transfer, thus leading to ineffective production competition.

Recent programs, such as AMRAAM, have initiated production competition efforts while in full-scale development (FSD). These programs cite risk reduction and improved design efforts as benefits of early involvement of two production sources. The second source contractors on these efforts provide the program manager with an additional engineering staff to address technical problems and offer alternative solutions.

The program manager should note that the second source for AMRAAM participated in the AMRAAM validation phase. Thus, when bringing the second source in during FSD, the program manager gained a supplier who was already familiar with system design and requirements. Rather than being faced with bringing a new source up to speed during a complex development effort, the AMRAAM program manager benefited from the immediate availability of a second design and production team.

The program manager could also effectively employ a new second source in parallel development of high-risk, critical components. This would enhance the probability of program success. Furthermore, the competitive sources, if successful, could be brought into production to ensure supply. This approach has been employed successfully by the Ballistic Missile Office on

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several strategic missiles, including TITAN, Minuteman, and the
Peacekeeper.[3]

In addition to design risk, the program may encounter
producibility risks if the required production buildup rate
places added stress on the program. If producibility problems
arise during a high buildup phase, the developer .ay not be able
to meet the delivery schedule. In that case, the involvement of
a second producer early may decrease the risk of a production
stop. The second producer can provide early technical assistance
by employing production techniques different from those employed
by the developer.

Schedule analysis and risk considerations must be
addressed in relation to unique program circumstances. The real
risks of technical deficiencies or production breaks must be
considered. In considering these factors, the program manager
must recognize the complexities associated with effective
technology transfer and second source qualification. These
complexities may require that the second source be qualified
later in the program than originally preferred.

Alternatively, the program manager should recognize the
opportunity to reduce risk through early involvement of a second

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"The Affordable Acquisition Approach Study: Data
Handbook," Air Force Systems Command, February 1983.

source. To achieve this benefit, second source involvement must be carefully planned and executed in relation to other program activities.

6.3   PRODUCTION LEAD TIMES

In assessing the timing of second source involvement, the program manager also must consider production lead times. If the program involves long production lead times, the second source may have to be involved in the program early to ensure delivery of production end items prior to the initiation of competitive awards. This in turn may determine the method of technology transfer. To investigate the effect of production lead times, the program manager can undertake the following steps:

(1)   Identify a preferred initial competitive award date using economic analysis.

(2)   Work back from that date to identify the proposal evaluation period.

(3)   Work back from (2) to identify an RFP release date and proposal preparation period.

(4)   Reflecting lead times, work back to a second source directed buy award date. The directed buy is used by the second source to demonstrate production rate capability. Thus, the award of a directed buy should be made early enough to ensure production deliveries prior to competitive bidding.

(5)   Based upon (4), identify a second source initial qualification date, initial unit fabrication, and technology transfer period.

These steps can be illustrated using a simple example,
as shown in Figure 6.3-1. The example assumes a production lead
time of 18 months, a proposal preparation period of 3 months, a
proposal evaluation period of 3 months, and a technology transfer
period of 12 months. It is also assumed that economic analysis
has indicated that the first competitive award should be no
later than the fourth production lot.

ACTIVITY	FISCAL YEAR					
	85	86	87	86	89	90
PRODUCTION START: INITIAL AWARD TO DEVELOPER	△					
SECOND SOURCE TECHNOLOGY TRANSFER	———					
SECOND SOURCE QUALIFICATION UNITS	——					
SECOND SOURCE QUALIFICATION	△					
DIRECTED BUY TO SECOND SOURCE TO DEMONTSTRATE RATE CAPABILITY (LOT 2)		△				
SECOND SOURCE DELIVERIES (LOT 2)				———----		
RFP RELEASE (LOT 4)				△		
PROPOSAL PREPARATION				——		
PROPOSAL EVALUATION (LOT 4)				——		
FIRST COMPETITIVE AWARD					△	

Figure 6.3-1   Production Lead Time Analysis

As shown in Figure 6.3-1, in order for competitive
awards to begin in lot four, the second source must be selected
prior to the initiation of production. Furthermore, the
technology transfer period must occur during the initial
production buy. Given this lead time schedule, the program
manager must either select a technology transfer method that

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achieves the schedule or delay the initiation of competitive awards.

In selecting a technology transfer method, the program manager must recognize that it is unlikely that a validated TDP could be prepared and released during FSD. Thus, to initiate technology transfer in FSD, a technique that does not rely on a validated TDP is required. In such a case, a leader-follower or licensing approach may be preferred.

These approaches present the program manager with an opportunity to attain early competitive awards while reducing production risk. If the second source were a subcontractor to the system developer, the developer could order long lead material for the entire second lot. A portion of the materials then could be provided to the second source for a learning buy, following second source qualification. This combined purchasing of long lead materials reduces the time required for the second source to demonstrate rate capability. In addition, if the second source fails to qualify, the system developer can proceed with production of the entire second lot. Thus, production risk is reduced.

Given the schedule shown in Figure 6.3-1, the program manager also could delay initiating competitive awards until the fifth production year. In such a case, a TDP approach may be viable; however, the lost savings due to delaying competition must be assessed.

The program manager should note that the example analysis presented in Figure 6.3-1 is highly simplified. Consideration of the lot three buy and long lead release should also be included in the analysis. Furthermore, the effect on the development effort of selecting the second source during FSD must be assessed.

6.4   DEGREE OF SUBCONTRACTING

The economic analysis presented in Chapter Four is based upon changing contractor price behavior in a competitive environment. Prior studies present empirical evidence to support the framework; however, the studies do not address how the price changes are achieved. If a large portion of the weapon system is subcontracted, the prime contractor may not be able to control a large portion of the weapon system cost. Thus, the potential price reductions associated with competition may be less than expected.

The program manager should review the degree of subcontracting when assessing the potential for production competition. This review should be based upon the developer's make-or-buy plan, as submitted during FSD. The results of this review may be used to adjust the economic analysis or to identify key subsystems for competition.

The review also is necessary to support analyses of the
supplier base. The review will provide the program manager with
preliminary planning insights in the area of second source
supplier qualification.

The program manager should note that a high degree of
subcontracting is not sufficient justification to forego
competition. In a competitive environment, it is likely that the
prime contractors will apply more pressure on their suppliers to
control costs than they would in a single source environment. It
is equally likely that the suppliers will respond, because, if
the prime loses the competition, the suppliers lose also.

6.5   LOWER TIERS

Production competition at the prime contractor level
requires an adequate supplier base. The existence of only one
supplier of a critical subsystem may reduce the benefits of
competition at the prime level. This supplier presents not only
a potential bottleneck but also a virtual monopoly. The two
prime contractors may be forced to vie against each other in
terms of delivery and price. The program manager can avoid the
potential adverse effects of a single subsystem supplier by
conducting a detailed subtier analysis. The results of this
analysis could then be used to develop alternative suppliers.

As an initial step in subtier analysis, the proprietary
data claims of existing subcontractors should be examined by

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either the government or the prime contractor to identify
proprietary designs and the costs to procure rights to such data.
The program manager must ensure that the claimed information is
indeed proprietary and then assess the criticality of the
proprietary claim. This process was employed recently on the
AMRAAM project when the two competing validation phase prime
contractors were asked to identify and cost proprietary data as
part of their FSD proposals.

Concurrently, the program manager should direct an
industrial base analysis to identify potential alternative
suppliers. This survey may involve producibility analyses or
Commerce Business Daily solicitations of interest. Such analyses
identify critical subtier limitations. The results of this
analysis may indicate that a new production source for a critical
component must be established. In such a case, the program
manager may request the prime contractor or the second source to
develop another supplier. Alternatively, the program office
itself could establish the second subtier supplier.

The program manager must recognize that competitive
production provides the prime contractors with an incentive to
develop reliable sources of supply to minimize their own risk of
supply interruption. This development effort may occur either as
expansion of in-house capabilities or as development of other
subtier contractors.

The establishment of alternative suppliers is a difficult task. Technology transfer must be accomplished and new suppliers must be qualified. The lead time associated with supplier qualification must be assessed in relation to the program schedule.

If the qualification lead times are excessive, the program manager may prefer a technology transfer technique, such as leader-follower, that allows the system developer to procure all subsystems initially. Secondary suppliers could be qualified later, without requiring a delay in the production program.

6.6   CONTRACTING AND LEGAL ISSUES

Any production program must be implemented contractually within the complex legal and regulatory framework established by the government. The program manager developing competitive production sources must resolve particularly perplexing issues involving source selection criteria, production award split methodologies, performance incentives, warranty provisions, and proprietary data. Accessible legal counsel and experienced contracting professionals are critical to successful resolution of these issues.

Accordingly, in assessing the potential for production competition, the program manager should determine whether sufficient legal and contracting personnel will be available during the program's implementation. If adequate legal and

contracting support cannot be secured, production competition may
not be viable.

6.7   PROGRAM MANAGEMENT COMPLEXITY

The development and implementation of a competitive
production program is an activity requiring a special team
dedicated to managing the competition. Obtaining such a team is
difficult when faced with DoD personnel constraints.
Furthermore, increases in program office staff may lead to
coordination difficulties.

The required level of personnel is determined in part
by the method of technology transfer. The TDP and F^3
approaches require the greatest amount of program office
involvement in the technology transfer process. Using an F^3
approach, the program office must develop and release an RFP,
monitor the second source's development effort, and qualify the
second source and associated suppliers. For a TDP approach,
program office involvement would also include verification and
guarantee of the technical data package.

The teaming approach also involves complex management
issues. The program office need not be involved with selection
of the second source; however, it must qualify both sources
simultaneously. Furthermore, the program office must closely
monitor technology transfer and the exchange of manufacturing
data.

The leader-follower and licensing approaches avoid many of these complexities. These approaches enable the program manager to delegate certain efforts to the system developer. These efforts may include selection of the second source, technology transfer, and second source qualification. Thus, the initial strain on program office personnel is reduced.

6.8   SUMMARY OF PROGRAM ANALYSIS

Production competition is a complex undertaking that influences every aspect of the program. Thus, in assessing the potential for production competition, the program manager must consider the relationship between competition and other program areas. Specifically, the program manager should undertake the following:

- Incorporate the additional up-front costs associated with competitive production into the program budget and assess the availability of funds.

- Assess the schedule and technical risks of introducing a second production source.

- Develop an integrated schedule that reflects production lead times.

- Consider subcontracting plans when predicting potential cost reductions associated with competition.

- Determine the ability of the lower tiers to support prime contractor competition.

- Assess the availability of expert legal and contracting personnel.

- Analyze the relationship between alternative technology transfer techniques and management complexity.

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7.   EVALUATION SUMMARY

Evaluation of production competition requires analyses in three areas:

- Economic
- Technical
- Program

This chapter summarizes the analyses presented in Chapters Four, Five, and Six. The purpose of this chapter is to provide the program manager with a checklist for easy reference during evaluation of production competition.

7.1   ECONOMIC ANALYSIS

When considering production competition as a tool to reduce program costs, the program manager must view the problem as an investment decision. The key considerations are reduced unit procurement costs versus additional up-front costs and increased government administrative costs. In addition, potential effects on maintenance and logistics costs must be considered. This trade off is unique for each program, requiring a program-specific analysis. The analysis presented in Chapter Four involves several steps which can be summarized as follows:

(1)   Estimate single source recurring production costs by fiscal year in constant dollars based upon progress curves and expressed as contractor price.

(2)   Estimate competitive recurring production costs by fiscal year in constant dollars based upon progress curves. Reasonable assumptions must be made concerning shift and rotation and the second source progress curve.

(3) Calculate potential savings by subtracting (2) from (1) by fiscal year.

(4) Calculate net potential savings by subtracting annual incremental government cost, stated in constant dollars, from (3).

(5) Estimate nonrecurring start-up costs, stated in constant dolla, by fiscal year.

(6) Estimate incremental logistic support costs, stated in constant dollars, by fiscal year.

(7) Calculate a net present value of competitive versus sole source production costs by subtracting the discounted costs (5) and (6) from the discounted benefits (3).

(8) Compare discounted, constant, and then-year dollar estimates of single source and competitive production.

(9) Conduct detailed sensitivity analyses to investigate the effect of changes in key assumptions on the estimate of savings, and to develop a range of likely estimates.

7.2   TECHNICAL ANALYSIS

In assessing production competition, a program manager must take into account the level and type of technology inherent in the system's design and manufacturing process. The system's technological characteristics influence the method of technology transfer, the economic analysis, source selection planning, and the program schedule. The technical analysis presented in Chapter Five requires that the program manager undertake the following:

- Assess the relative attractiveness of the technology transfer techniques in relation to the level and type of technology involved.

- Incorporate the technology aspects of the program into the source availability analysis.

- Investigate the potential for design or manufacturing innovation.

- Incorporate the potential for follon-cn development efforts into the production competition strategy.

- Ensure that proprietary data embedded in the system design has been identified and priced.

7.3   PROGRAM ANALYSIS

In addition to economic and technical issues, the program manager should conduct analysis of key program issues. In performing the analysis of program issues presented in Chapter Six, the program manager should undertake the following:

- Incorporate the additional up-front costs associated with competitive production into the program budget and assess the availability of funds.

- Assess the schedule and technical risks of introducing a second production source.

- Develop an integrated schedule that reflects production lead times.

- Consider subcontracting plans when predicting potential cost reductions associated with competition.

- Determine the ability of the lower tiers to support prime contractor competition.

- Assess the availability of expert legal and contracting personnel.

- Analyze the relationship between alternative technology transfer techniques and management complexity.

PART THREE

IMPLEMENTATION OF
PRODUCTION COMPETITION

8.   PRODUCTION COMPETITION PLANS

Many of the problems encountered on prior production competition programs surfaced during their implementation phase. Fortunately, the program manager can avoid most of the problems of prior efforts through careful, early planning.

Often, the planning associated with production competition is documented in a number of plans, strategy papers, and budget books. This dispersion of documentation greatly complicates the implementation and execution of a competitive production program. Therefore, the program manager should develop a single, integrated production competition plan that addresses all critical issues, which include the following:

- Technology transfer
- Selection of the second source
- Contractual arrangements
- Second source qualification
- Schedule
- Configuration management
- Funding

The purpose of this chapter is to present a general introduction to these areas. Specific implementation actions associated with particular technology transfer approaches are presented in Chapters Nine through Thirteen.

8.1 TECHNOLOGY TRANSFER

The production competition plan must address two critical areas related to the technology transfer:

- The availability of adequate technical data
- The level of support required from the system developer

The availability of adequate technical data to the program office and the second source is an integral component of a successful production competition program. The level of data required depends upon the method of technology transfer. For example, a TDP approach requires a detailed data package that includes all critical design and process information. A leader-follower approach may require less documentation, but more continuing engineering support. The production competition plan should delineate all required design and production data, as well as test requirements, special test equipment drawings, quality assurance requirements, and approved engineering change orders.

To enhance technology transfer and to reduce the risk of inadequate documentation, the program manager may request the system developer to warrant the technical data package. If such an approach is envisioned, the program manager should reflect this in the production competition plan and obtain contractor agreement to the warranty provision prior to FSD.

The system developer may resist providing complete documentation on the grounds of proprietary data. The program

manager can obtain rights to proprietary data by requesting the
competing developers to identify and price all proprietary data
embodied in their designs as part of their FSD proposals. The
availability of data and the cost of data could be employed as
explicit source selection criteria. This approach enables the
program manager to obtain rights to proprietary data early in the
program, in a competitive environment. The specific actions
related to this approach should be discussed in the production
competition plan.

The required level of support from the system developer
also should be described in the production competition plan. The
developer's support could involve several activities, depending
upon equipment complexity, program schedule, and the desired
level of commonality between the two producers' equipment. These
activities include the following:

- Technical data package preparation

- Provision of key subsystems, or the entire system,
  to the second source

- Direct technical assistance and consultation

- In-plant assistance

- Licensing of proprietary data

- Development of subtier suppliers

Prior to FSD, the program manager must make an
independent assessment of the desired level of developer support,
considering the technology transfer method. The desired level of
support then should be included in the FSD solicitation as an
option and defined in the production competition plan.

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Ensuring adequate support from the system developer may require special incentives. For example, award fees have been employed successfully on prior production competition programs. In addition, innovative incentives have been developed that base the developer's progress payments on the progress of the second source. The incentives adopted by the program should be clearly delineated in the production competition plan.

8.2   SELECTION OF A SECOND SOURCE

The production competition plan must describe the process for selecting the second source. The second source can be selected either by the government or by the system developer. In the first case, the government would solicit and select the second source, leading to the award of a prime contract to the second producer. Another method is to allow the system developer to solicit and select the second source subject to program office approval. In this latter case, the system developer would prepare and execute a source selection plan covering planning, RFP preparation, solicitation, proposal evaluation, and award. The second source would be a subcontractor to the developer during the technology transfer period.

Both methods have been employed successfully on prior competitive production programs. Whichever method is selected, the program manager must ensure that the production competition plan reflects the following:

- Second source qualification criteria, including engineering, manufacturing, cost, and capacity requirements

- A source selection plan that is in accordance with the program schedule

- Degree of program office control over source selection and final approval of the selected second source

8.3   CONTRACTUAL ARRANGEMENTS

Two of the technology transfer techniques involve separate contracts with the two producers. The TDP and F^3 approaches are contractually implemented in this manner. For these techniques the production competition plan should describe the type of contracts, the incentives to be used, and anticipated contract funding levels.

For other technology transfer techniques, the production competition plan must address the contractual arrangements in more detail. For example, when using a leader-follower or a licensing technology transfer technique, the government can establish the second source using either of the following contractual approaches:

- A clause could be included in the developer's FSD contract specifying that a certain portion of the developer's initial production be subcontracted to a second source. The developer would be responsible for technology transfer, production qualification, and acceptance tests of the second source's initial production units.

- The second source could be a prime contractor to the government and technology transfer could be accomplished through a separate engineering services contract with the system developer.

Similarly, contractor teaming can be implemented using either a subcontract cr joint venture approach.

The alternative contractual approaches have associated advantages and disadvantages. For example, establishing the second source as a subcontractor reduces the administrative burden on the program office; however, it also reduces program office control over the technology transfer process. Each approach also affects other implementation planning areas in different ways, depending upon the specific technology transfer technique. For example, establishing the follower as a subcontractor to a leader company may result in the leader company performing follower qualification. On the other hand, the use of a subcontract arrangement for contractor teaming does not affect the requirement for government qualification of both producers.

Given a stated technology transfer technique, the production competition plan should present the advantages and disadvantages of alternative contractual approaches in relation to program characteristics. In assessing the relative advantages and disadvantages of the two approaches, the program manager should consider the following:

- Program office personnel requirements
- Program office access to the second source
- Program office control over the technology transfer process

- Contractor cooperation and motivation in developing a second source

8.4 SECOND SOURCE QUALIFICATION

Production qualification of the second source can be achieved either by the government or the system developer, depending upon the technology transfer method and the contractual relationship between the producers. Both of these methods have been employed successfully on prior programs. In developing a production competition plan, the program manager should ensure that the plan addresses the following:

- Schedule
- Qualification responsibilities
- Quality assurance
- Tooling
- Test equipment
- Suppliers

In Chapters Nine through Thirteen, these areas are discussed in specific reference to the various technology transfer methods.

8.5 SCHEDULE

The production competition plan should present an integrated milestone schedule for second source selection and qualification. This schedule should reflect ongoing program activities in other areas, as well as critical production competition milestones. The schedule should work back from the

desired second source qualification date and initial competitive
award date. Potential milestones include the following:

- Initial management meetings
- Design briefings and engineering exchange
- Data item delivery
- Subassembly delivery and inspection
- End item disassembly, inspection, and reassembly by the second source
- Subassembly fabrication and test
- End item fabrication
- Production qualification
- Release of RFP for initial competitive production
- Competitive proposal submission
- Source selection and award
- Long lead release

The exact activities related to each of these
milestones would be defined by program characteristics. The key
is to identify relevant milestones and tie those milestones to
the developer's contract. The program manager then has a useful
tool to monitor progress and to motivate the developer.
Furthermore, an integrated schedule will provide the program
manager with insights relevant to production planning, long lead
release dates, and competitive solicitation.

8.6   CONFIGURATION MANAGEMENT

In developing a production competition plan, the
program manager must address configuration management issues.

The system developer typically maintains configuration control up to Critical Design Review (CDR); however, the program office may assume configuration control earlier to avoid design changes that adversely affect competition. The competition plan should present a configuration control milestone. In addition, the plan should define the structure of the Configuration Control Board. To enhance competition, both contractors should be represented on the board. Similarly, the processing and control procedures applicable to Class I and Class II Engineering Change Proposals (ECPs) should be discussed.

8.7   FUNDING

The production competition plan must identify all required funding necessary to implement the production competition program. The funding requirements should be delineated by appropriation category. For example, research and development funds may be required for technical data rights, second source development efforts, qualification testing, and engineering services associated with technology transfer.

Similarly, production funds may be required for additional tooling, as well as for production end items. The production or procurement accounts should clearly present annual procurement quantities and projected funding requirements by line item. This will enhance the program manager's ability to assess the effect of potential budget reductions on the competitive production program.

8.8   CONTENTS OF A PRODUCTION COMPETITION PLAN

Deliberate and thorough planning is essential to the success of a production competition program. The specific contents of a plan are determined by program circumstances; however, there are several general areas that should be included in all production competition plans. Figure 8.8-1 presents a sample outline of a production competition plan to assist the program manager in developing a plan for a particular program.

1. OVERVIEW
   1.1 System Description
   1.2 Technology Transfer Approach
   1.3 Structure of the Plan

2. MANAGEMENT ORGANIZATION
   2.1 System Developer
   2.2 Second Source
   2.3 Program Office

3. TECHNOLOGY TRANSFER
   3.1 Data to be Transferred
   3.2 Proprietary Rights
   3.3 Required Technical and Management Support
   3.4 Engineering Assistance
   3.5 Manufacturing
   3.6 Subcontractors and Suppliers

4. SELECTION OF THE SECOND SOURCE
   4.1 Responsibilities
   4.2 Selection Criteria

5. CONTRACTING
   5.1 Contractual Arrangements Between Producers
   5.2 Contractual Arrangements Between the
        Government and the Producers

6. PRODUCTION QUALIFICATION
   6.1 Philosophy
   6.2 Existing Design
   6.3 Potential Improvements

7. MASTER SCHEDULE
   7.1 Source Selection
   7.2 Lead Times
   7.3 Qualification
   7.4 Schedule Milestones

8. CONFIGURATION MANAGEMENT
   8.1 Responsibilities
   8.2 Configuration Control Board
   8.3 Configuration Control Procedures

9. BUDGET
   9.1 Development
   9.2 Production

Figure 8.8-1   Production Competition Plan

9. FORM, FIT, AND FUNCTION

Form, Fit, and Function (F^3) is a technique for establishing competitive production sources in situations where internal design commonality is not required. As discussed in Chapter Two, the F^3 technique involves solicitation of alternative suppliers based upon performance and external interface specifications. Internal design and manufacturing flexibility are allowed and encouraged.

The F^3 technique has been employed successfully for relatively simple components such as the GAU-8 30-millimeter ammunition. The technique also has been used for complex items such as the Alternate Fighter Engine. Thus, the F^3 approach may be applicable at two ends of a broad spectrum. For simple components where logistic support is minimal, the F^3 technique is appropriate. At the other end of the spectrum, an F^3 approach may be appropriate for complex items if the cost reductions due to production competition far outweigh potential increases in logistics costs. These characteristics of an F^3 technique present unique implementation issues in the following areas:

- Second source selection
- Original source support
- Technology transfer
- Second source qualification
- Logistic support

9.1   SECOND SOURCE SELECTION

The use of an F^3 technique at the system level requires that the program office incorporate the performance requirements of the equipment into a Request for Proposal which is released to potential second sources. Proposal evaluation and source selection are performed by the program office.

The program manager must recognize that the F^3 technique may require that development work be performed by the second source. For complex items, the ability of the second source to conduct design engineering and to develop the equipment efficiently is crucial to a successful F^3 program. Thus, source selection criteria should emphasize design as well as production capabilities.

For complex items, the program manager should consider the concurrent development of the system by both producers. This approach may require additional development funding up-front; however, it presents the benefit of having two design teams competing head-to-head, knowing that they also will be competing for production. Such an approach should improve the producibility of the design. In addition, this approach reduces program development risk. The program manager should note that

the use of this approach requires that the program acquisition strategy be well defined prior to full-scale development (FSD).

In addition to design capability, the second source must possess demonstrated capabilities in transitioning a system from development into production. In the end, an F^3 approach is successful only if the second source can smoothly transition into production as a true competitor.

Since no technology transfer takes place under an F^3 technique, and there is no technical data package, the program manager must ensure that the equipment specification is clearly and completely defined prior to solicitation of the second source. The equipment specification must be detailed to a level that is sufficient to allow potential second producers to prepare realistic proposals. The specification should include the following:

- External dimension of the equipment
- Interface requirements
- Power requirements
- Equipment performance requirements

9.2   ORIGINAL SOURCE SUPPORT

The F^3 technique, by its nature, does not require the support of the original developer. In fact, the F^3 technique has been used in prior programs to improve the program manager's leverage when dealing with an uncooperative contractor.

For example, this technique initially was suggested for the cruise missile engine when the system developer refused to cooperate in a competitive production program.

9.3 TECHNOLOGY TRANSFER

Under an F^3 technique, technology transfer is achieved through publication of the equipment specifications. The second source is constrained only by the external interface and performance requirements of the equipment. The internal configuration of the equipment is left to the second source. The program manager must recognize that this requires that the equipment specification be clearly defined. Inadequate product specifications could preclude the successful development of a second source.

The quality of the equipment specification is related to the program's phase in the acquisition process. If the F^3 technique is used to develop a second source after the initial source has entered production, then the specification will be well defined. On the other hand, if the F^3 technique is used during the early design phase of a program, the equipment specification may be evolving. In such a situation, the program manager may use preliminary interface and performance specifications to solicit a second source. This approach may necessitate negotiation of detailed specifications at a later date.

9.4   SECOND SOURCE QUALIFICATION

The design flexibility afforded the second source provides considerable opportunity to reduce production costs; however, it may complicate second source qualification. Because the internal configurations differ, the second source probably cannot be qualified on the same test equipment as that used for the first source. Consequently, the program manager should anticipate additional special test equipment costs when employing an F^3 technique. Additionally, the program manager should plan for increased program office effort in conducting in-plant reviews, production readiness reviews, test of the second source's initial items, and audits.

9.5   LOGISTIC SUPPORT

In implementing the F^3 technique, the program manager should anticipate additional logistic support complications, due to the internal equipment configuration differences afforded the contractors. These complications should be considered early in the program so that potential trade offs can be investigated.

For example, if the F^3 technique is employed to develop competitive suppliers of an on-board subsystem, configuration differences may require two different sets of intermediate level test equipment. In such a situation, the program manager should investigate the potential cost effects of

this requirement when developing the system maintenance concept. After evaluation, the program manager may conclude that an organic intermediate level maintenance capability is not cost efficient. The equipment could be returned to the manufacturer for repair either under warranty or under a fixed-price repair contract. In such a case, these provisions could be used as source selection criteria when determining the production award split.

In addition to test equipment, the program manager must consider all logistics elements when implementing an F^3 program. The different configurations may require unique documentation, special training, peculiar support equipment, distinct provisioning requirements, and different maintenance facilities. These potential impacts should be considered when developing the F^3 implementation plan and the system maintenance concept.

A recent example of a complex F^3 program is the Alternate Fighter Engine. This program successfully employed the F^3 technique and developed a maintenance concept that utilized existing facilities and reflected the F^3 buy. Specific areas include the following:

- Warranties of the two engines were included in the acquisition and obtained competitively.

- Training and technical orders also were included in the acquisition and thus were subject to the competition.

- Intermediate level support equipment was developed to be adaptable to both engines.

- Existing depot facilities that currently service similar engines will be employed for the new engines.

9.6 F^3 IMPLEMENTATION

The F^3 technique differs from other technology transfer techniques in that internal configuration differences between the two producers' equipment are allowed and encouraged. In implementing th F^3 technique the program manager should undertake the following:

- Ensure the equipment specification is clearly and completely def ned prior to solicitation of the second source.

- Anticipate the need for additional special test equipment and program office effort in conducting production qualification.

- Consider the potential for logistic support cost increases due to fielding two configurations.

10.   TECHNICAL DATA PACKAGE

The technical data package (TDP) technique of establishing competitive production sources ordinarily is used for items of low to moderate complexity, such as the AN/APM-123 transponder test set. Also, in a few cases, a TDP technique has been used successfully to develop second sources for complex items, such as the AIM-7F tactical missile.

Technology transfer is achieved strictly on the basis of the TDP with no direct contractor-to-contractor exchange. Therefore, the key criterion in determining the use of the TDP technique is that the system technology be such that it can be adequately presented as drawings, specifications, parts lists, and processes.[1] These characteristics present special implementation concerns in the following areas:

- Second source selection
- Original source support
- Contents of the TDP
- TDP validation and transfer
- Second source qualification

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[1]For a more detailed discussion of the application of the Technical Data Package technique, see: "Review of the AIM-7F SPARROW Second Source Procurement Program," The BDM Corporation, December 1980.

10.1   SECOND SOURCE SELECTION

In a typical TDP program, the second source is selected and qualified by the government based on competitive bids. Thus, the program office must prepare and release a Request for Proposal (RFP), evaluate the proposals, and select a second source. Prior to releasing the RFP, the program office must have a validated TDP that can be used by potential second sources to develop proposals.

The program manager can attain a validated TDP by freezing the system configuration following initial production, by which time configuration changes resulting from producibility problems will have been accomplished. Once initial producibility changes have been documented and the design frozen, potential second sources can be solicited. The program manager should note that these activities preclude introducing the second source until the second year of production, at the earliest.

Reliance strictly on the TDP for technology transfer also dictates that the second source possess design engineering and manufacturing capabilities. The second source may be required to undertake reverse engineering of selected subsystems or components. Thus, the program manager should stress design capability in the source selection criteria.

The TDP approach allows full program office control over the second source selection process. The government

determines the source selection criteria, the contractors to be solicited, and the winning contractor. By ensuring full control, this method decreases the risk of selecting a noncapable second source.

A direct government-to-contractor relationship is established, thus enhancing technical exchange between the program office and the second source. Furthermore, the program office can directly monitor the progress of the second source in technology transfer and production qualification.

10.2   ORIGINAL SOURCE SUPPORT

In a TDP program, the program manager should concentrate on obtaining support from the original source in developing an adequate TDP in a timely manner. The program manager could enhance this support by procuring unlimited data rights early in the design phase of the program. In addition, the program manager may request the developer to warrant the TDP. If a warranty is desired, it should be specified in the RFP for the full-scale development (FSD) contract, to allow the program manager to obtain the warranty in a competitive environment. To enhance further the development of an adequate TDP, the program manager could employ additional incentives, such as award fees.

10.3   CONTENTS OF THE TDP

In order to develop a second source in a timely manner, the program manager must ensure that the TDP presents a detailed description of the item being procured.[2] The key contents of such a description would include the following:

- Product specifications
- Engineering drawings and associated lists
- Quality assurance provisions

Additionally, for complex items, the program manager should attempt to incorporate into the TDP the manufacturing process information associated with key subsystems. Finally, the TDP should including the following:

- Packaging data sheets
- Acceptance inspection equipment drawings
- Concurrent repair parts lists
- Special production tool drawings

These items must be incorporated in the TDP in accordance with all relevant DoD standards.

The product specification is the document which clearly describes the essential technical requirements for the product being procured, including the procedures by which the determination is made that the requirements have been met. In

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[2]For a more detailed discussion of the contents and validation of a TDP, see: "Technical Data Package Development and Management," Army Management Course, United States Army Management Engineering Training Activity, October 1982.

addition, the specification also may include requirements related to packaging, handling, and marking. The product specification is the primary document on which the program manager relies for configuration control. Thus, in a competitive production program, the equipment specification must be clearly and accurately incorporated into the TDP.

The program manager should note that the development of product specifications is an evolutionary process that begins in the early design phases of a program. As the design is developed, the specification becomes increasingly more detailed. During FSD, detailed design specifications and drawings are prepared to form the product specification. The production specification serves as the basis for the product baseline and is crucial to defining the item. Thus, the product specification is a key component of the TDP.

Another key component of the TDP is the engineering drawings and associated lists that define in detail the composition of the equipment. An engineering drawing discloses by means of pictorial or textual presentation, the physical and functional end product requirements of an item. An associated list is a tabulation of engineering data pertaining to an item depicted on an engineering drawing or on a set of drawings. Several types of engineering drawings combined into sets with attendant associated lists may be required to define end product requirements of an item. As a minimum, a combination of detail and assembly drawings may suffice to define the requirements of a

simple item. As the complexity of the item increases, specialized engineering drawings may be required to provide a full engineering description. As a rule, combinations of detail, assembly, control, installation, and diagrammatic drawings will provide the necessary engineering description. In certain cases, special purpose drawings may be required for management control, logistic purposes, configuration management, and manufacturing aids.

Quality assurance data are also a key component of the TDP. Incorporation of quality assurance provisions in the TDP will enhance the competitive production of end items that meet operational requirements. The TDP should present a detailed plan of all actions necessary to ensure that the end item meets all stated requirements. The program manager must ensure that the plan contains all technical information related to product quality. This may include the following:

- Contract quality requirements in regard to contractor responsibility, standard inspection requirement, inspection system requirement, and quality program requirement

- Identification of examinations and tests to be performed by the contractor

- Method of performance of required examinations and tests

- Inspection equipment authorized or required

- Statistical techniques authorized

- Qualification approval requirements

- Acceptable quality levels

- Classifications of defects

- First article tests

- Calibration requirements

- Records of examinations and tests

- Standards of workmanship

- Quality requirements to be passed on to vendors or suppliers

- Examinations or tests reserved for performance by the government

- Nondestructive test procedures

- Personnel skill qualifications and certification

- Methods for analyzing inspection results

- Environmental tests

- Life tests

- Reliability production acceptance tests

In addition, the project manager may be able to obtain process information from the system developer. If such information can be obtained, the following should be included in the TDP:

- Logic diagrams

- Interface control drawings

- Development specifications for prime and critical items

- Product fabrication specifications for critical items

- Process and material specifications

- Purchase descriptions

- Data processing system requirements

- Installation drawings

- Unique manufacturing data

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Equal in importance to the content of the TDP is the format in which required data are presented. The program manager should ensure that all data presentations conform to applicable DoD standards. Contractors and government personnel understand these standards and expect data to be presented in accordance with them. Insisting on conformance to standards in preparing the TDP will enhance validation of the TDP and subsequent production from the TDP. Some of the more critical standards include the following:

- MIL-STD-961, 22 September 1975, Outline of Forms and Instructions for the Preparation of Specifications and Associated Documents. This standard covers specifications for commodities, processes, and the control of weapons, systems, and subsystems design.

- MIL-STD-490, 30 October 1968, Specification Practices. This standard establishes the format and contents of specifications for program peculiar items, processes, and materials.

- DoD-STD-100C, 22 December 1978, Engineering Drawing Practices. This standard prescribes general requirements for the preparation and revision of engineering drawings and associated lists prepared by or for the Department and Agencies of the Department of Defense.

The program manager should note that the documentation requirement associated with the TDP technique is extensive. If the second source is being introduced early during production, the technical documentation may not be complete. In such a case, a time-phased delivery of complete design information should be established by the program manager.

10.4   TDP VALIDATION AND TRANSFER

The program office must validate the TDP. The drawings must be compared to the equipment for consistency, the specifications must be reviewed, and the process information must be evaluated. In reviewing the TDP, the program manager should assess whether it is:

- Accurate
- Current
- Complete
- Clear

An accurate TDP is one which is free of mistakes and errors. Potential errors include incorrect dimensions, incorrect material specifications, obsolete data, and design deficiencies. Any of these errors could preclude successful production of the item by a second source.

A current TDP is one which includes only that documentation relevant to the existing configuration. In a current TDP, obsolete data have been removed and updated data reflecting engineering changes have been incorporated. The use of obsolete data or the omission of engineering changes could delay successful qualification of the second source.

A complete TDP is one which includes all relevant data necessary to produce and deliver equipment that meets operational

requirements. The completeness of the TDP can be reviewed based upon the list presented in on page 10.4.

A clear TDP is one which conforms to DoD standards concerning drawings, documentation, and models. The TDP should be concise, but inclusive.

TDP validation activities may require support from other government agencies. For example, the Naval Weapons Center supported validation of Raytheon's AIM-7F TDP. The program manager must recognize that by validating the TDP, the program office is assuming responsibility for its adequacy. Thus, to avoid potential future claims, the program office must ensure that the validation effort is thorough and rigorous.

Once validated, the TDP can be transmitted to the second source, who must translate it to the firm's design systems and manufacturing processes. The program manager should note that this process may involve significant effort if the two manufacturers employ different production processes. Following design translation, the second source can begin to fabricate test articles.

In order to ensure efficient technology transfer using a TDP technique, the program manager should address technology transfer in detail in the production competition plan. The plan would include the following:

- Technology items to be included in th · TDP

- A milestone schedule showing TDP preparation, validation, and delivery to the second source

- Special incentives or warranties used to motivate the developer to provide an adequate data package in a timely manner

10.5 SECOND SOURCE QUALIFICATION

The government assumes responsibility for qualification of the second source under a TDP approach. Thus, the program manager should anticipate conducting in-plant reviews, production readiness reviews, and acceptance tests of the second source's initial articles. If the two manufacturers' end items are common, the second source's end items should be tested on the same equipment used to test the developer's equipment. This will require the establishment of duplicative test equipment at the second source's facility. Because the TDP approach presents the potential for producibility changes by the second source, the program manager also should anticipate requirements for special test equipment at the second source's plant.

In addition, the second source should be required to demonstrate capability to produce at rate prior to competitive bidding. To accomplish this, the program manager may direct a large "learning buy" to the second source following production qualification.

10.6   TECHNICAL DATA PACKAGE IMPLEMENTATION

The technical data package technique for establishing competitive production sources requires a high level of program office effort. In conducting a TDP program, the program manager should undertake the following:

- Select a second source with adequate design and manufacturing experience.

- Anticipate the requirement for positive and negative incentives to motivate the developer to assemble an adequate data package.

- Qualify the second source, recognizing that special test equipment may be required.

- Consider the use of a learning buy to enable the second source to demonstrate rate capabilities prior to competitive bidding.

11.   LEADER-FOLLOWER

The leader-follower technique achieves technology transfer through direct technical assistance from the system developer or leader to the second source. It has been employed on several prior and ongoing programs, including DRAGON, SHILLELAGH, AMRAAM, and TOMAHAWK.

Leader-follower is to be used when the design or manufacture of a system is such that a second producer would be unable to produce the system without assistance from the developer.[1] The direct contractor-to-contractor exchange enhances the technology transfer of more complex weapon systems while minimizing government involvement in technical data validation. These characteristics present unique implementation issues in the following areas:

- Contractual arrangements
- Follower selection
- Leader support
- Technology transfer
- Follower production qualification

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[1]Charles W. N. Thompson and Albert H. Rubenstein, "The Leader/Follower Concept in Acquisition," International Applied Science and Technology Associates, Inc., November 1979.

11.1 LEADER-FOLLOWER CONTRACTUAL ARRANGEMENTS

The leader-follower technique can be implemented contractually in three ways. According to FAR Subpart 17.4, a prime contract could be awarded to a:

- Leader company, obligating it to subcontract a designated portion of the required end items to a specified follower company and to assist it to produce the required end items.

- Leader company, for the required assistance to the follower company, and a prime contract to the follower for production of the items.

- Follower company, obligating it to subcontract with a designated leader for the requisite assistance.

The third technique requires the follower to award a contract to the leader to obtain the necessary assistance; however, the leader is not contractually obligated to accept the contract Thus, the developer may refuse the contrac.. thereby precluding a leader-follower program. Given this potential problem, the third technique has not been used on any prior DoD programs. Therefore, the remainder of this chapter will concentrate on the advantages and disadvantages of the other two approaches.

The Follower as a Subcontractor to the Leader

As described in the FAR, the leader-follower approach can be implemented contractually by establishing the follower as a subcontractor to the leader. This approach can be implemented

by requiring the leader to develop a leader-follower plan during FSD. The activity associated with the development of a plan should be solicited in the FSD Request for Proposal (RFP) and includes the following:

- Source selection
- Technology transfer
- Follower qualification

The program manager should require the leader-follower plan to be a contract deliverable during FSD. Following program office approval, the plan could be incorporated as an option in the developer's initial production contract.

Under this approach, the leader normally selects the follower and provides technical assistance and data to the follower. The follower is awarded a subcontract for a limited number of the developer's initial production units. Thus, the developer is responsible contractually for the follower's deliveries. After follower qualification, the leader and the follower would compete as prime contractors for production awards.

One of the key advantages of the subcontract approach is the leader's contractual responsibility for the follower's initial deliveries. This presents the program manager with an opportunity to employ innovative incentives, as discussed in Section 11.3. In addition, the program office is not involved directly in the selection process or technology transfer process. This lessens the administrative burden on the program office. It

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is important, however, that the program manager maintains complete visibility into the activities related to selection of the second source and into the technology transfer process. In addition, the program manager must monitor the progress of the second source in achieving production qualification.

The Follower as a Prime Contractor to the Government

Another contractual method to implement a leader-follower program is to award a prime contract to the follower. In this case, the government would select the follower and award the contract to the follower to learn the system and demonstrate production capability. Technology transfer would be accomplished under a separate government contract with the leader.

The leader technology transfer effort could be obtained through a task in the leader's FSD contract. This effort should be solicited as part of the FSD RFP, thus allowing the program manager to place the task on contract during the competitive selection of an FSD contractor. The leader's technology transfer tasks also could be contracted on a separate engineering services contract. Such a contract could be awarded during FSD or initial production. Under either approach, the program manager should ensure that the leader's tasks include the following:

- Transfer of all required design data
- Transfer of all required manufacturing data

- Provision of key subsystems or the entire system for follower inspection

- Provision of a duplicate set of test equipment

- Preparation and maintenance of a detailed milestone schedule

The program manager should note that the prime contract approach also requires that the two contractors enter into a direct agreement concerning technology transfer. This agreement may be a formal associate contract or a memorandum of agreement. The agreement should clearly define the responsibilities of the leader and the follower.

The prime contract approach has the advantage of establishing a direct follower-government relationship immediately. Thus, the program office can monitor technology transfer more readily. Furthermore, production buys can be awarded directly to the follower for qualification and initial learning.

The prime contract approach also places immediate pressure on program office personnel. Increased staffing will be required to monitor two contractors in addition to technical support to manage the technology transfer effort. This approach also may lead to the selection of a follower that is unacceptable to he leader. Forcing cooperation may complicate technology transfer and slow follower qualification.

A Contractual Arrangement

Both of the contractual techniques have been used successfully on prior DoD leader-follower programs. The subcontract approach was employed on the ACES II program. The SHILLELAGH and DRAGON programs used the prime contract approach. In selecting an approach, the program manager must weigh additional staffing and complexity against increased visibility.

11.2   FOLLOWER SELECTION

Under a leader-follower approach, the follower can be selected either by the government or by the system developer. In the first case, the government would solicit and select the follower, leading to the award of a prime contract to the follower. Another method is to allow the system developer to solicit and select the follower, subject to program office approval. In this case, the leader would develop and execute a source selection plan, solicit proposals, evaluate them, and award a subcontract that would cover follower activity through the technology transfer period.

Program Office Selection of the Follower

The program manager may desire to solicit and select the follower. Using this approach, the program office must undertake the following:

- Obtain sufficient technical data from the leader to allow potential followers to bid.

- Prepare and release a follower RFP.

- Evaluate potential follower proposals.

- Select a follower and negotiate an award.

- Ensure that the technology transfer between the leader and follower is understood by both parties.

The key difficulty in these program office tasks is obtaining data from the leader for inclusion in the follower solicitation. The program office must obtain unlimited rights to the data early. If the follower RFP is released in FSD, the required data may not be available. In such a case, the RFP should include sufficient design information to enable potential bidders to understand the magnitude of the effort.

In evaluating the proposals, the program office should concentrate on those capabilities that are required by the specific nature of the program. For example, demonstrated production experience may be sufficient for a relatively short production program, since the leader will be providing direct assistance. If product improvements are planned for the future, the follower should possess design capabilities.

This approach ensures full program office visibility into the follower selection process, decreasing the risk of selecting a noncapable follower. A direct relationship between

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the government and the follower is established, enhancing
technical exchange between the program office and the follower.
Furthermore, the program office can directly monitor the progress
of the follower in technology transfer and production
qualification.

While this method enhances government visibility, it
also requires considerable program office administrative effort.
In addition, there is no direct link between the system developer
and the follower. The leader may be less than enthusiastic about
transferring technology to another firm that the leader played no
role in selecting. This potential problem can be avoided by
allowing the leader to participate in the selection of the
follower, under the direction of the program office.

Leader Selection of the Follower

The system developer can solicit and select the
follower, subject to program office approval. This approach
generally entails establishment of the follower as a
subcontractor to the leader. Thus, the leader would undertake
the following:

- Prepare a follower solicitation.
- Evaluate the proposals.
- Select a follower.
- Submit the selection for program office approval.

Under this approach, the leader performs the majority of the
administrative effort.

The program manager should ensure that the leader's efforts are defined clearly in a milestone plan that is contractually binding. Furthermore, the program manager should ensure that a capable follower has been selected, by conducting site surveys and audits.

The key advantage of this approach is that it limits program office administration and liability associated with technology transfer. Furthermore, leader selection may enhance technology transfer by enabling the system developer to select a follower that he can work with.

This approach also presents several disadvantages. The leader may select a follower who is incapable of true competition. The follower may be production qualified: however, the firm may never demonstrate rate capabilities. Similarly, the follower's cost structure may be such that the firm could never win a competitive award against the leader.

Another disadvantage of this approach is the lack of a direct link between the government and the follower during technology transfer. The program manager has no contractually-based control over the follower, but must rely on the leader to ensure timely development of the follower.

Selection of the Follower

Both of the methods for selecting a follower have been employed successfully in prior leader-follower programs. Neither method can be preferred over the other based on historical experience. The program manager must choose a method to select the follower based upon specific program circumstances. Whatever method is selected, the program manager must ensure that follower source selection is planned in accordance with the program schedule. Furthermore, the source selection criteria should stress the capabilities of the follower in areas such as engineering, manufacturing, cost, and capacity. These capabilities should be demonstrated by the prior experience of potential followers, especially in similar programs.

11.3 LEADER SUPPORT

The support of the leader is crucial to a successful leader-follower production program. The required level of support could involve several activities depending upon equipment complexity, program schedule, and the desired level of commonality between the two producers' equipment. Potential activities include the following:

- Provision of all required technical data
- Provision of key subsystems or the entire system to the follower
- Direct technical assistance and consultation

- In-plant assistance

- Development of subtier suppliers

The leader-follower approach is employed for relatively complex systems which require considerable assistance to the follower. For example, the leader may be required to provide key subsystems or the entire system t the follower for disassembly, inspection, and reassembly. Similarly, the leader may be required to provide direct technical assistance in the form of design reviews, subsystem testing, and mock-up reviews.

It may be necessary for the leader to provide in-plant assistance to the follower, if the systems or manufacturing processes are complex. Because of concern over disclosure of unique manufacturing processes, developers and followers have resisted in-plant exchange of personnel on prior production competition programs. Thus, the program manager should ensure the selection of a capable follower with demonstrated production abilities.

The program manager may require the leader to undertake actions relative to the subtiers, if critical subsystems are claimed as proprietary. For example, the leader may be required to develop alternative suppliers. This would enhance follower qualification as well as future competition.

As presented, the leader-follower technique requires an extensive amount of support from the leader. To ensure leader

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support, the program manager may employ positive and negative incentives.[2]   Positive incentives may include the use of award fees to the leader.

Negative incentives are strong motivators that should be considered by the program manager also. For example, the leader's progress payments could be tied to demonstrated follower progress. A negative incentive that may be used when the follower is a subcontractor is to require the leader to meet the follower's delivery schedule at no cost to the government.

11.4   TECHNOLOGY TRANSFER

The leader-follower technique involves direct technical exchange between the contractors. Prior to this exchange, the program manager should address technology transfer issues in detail in the production competition plan. Often, the leader defines technology transfer tasks that are approved by the program office. The production competition plan should define the following areas of the technology transfer effort:

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[2]For a more detailed discussion, see Rosemary Elaine Nelson, "Leader/Follower Second Sourcing Strategy as Implemented by the Joint Cruise Missiles Project Office," Naval Postgraduate School, September 1980.

See also Larry L. Soderquist, "Leader/Follower: An Analysis of a Proposed Technique for Increasing Competition in Air Force Weapon System Procurements," Air Force Institute of Technology, September 1979.

- The technology items to be transferred

- Leader, follower, and program office responsibilities

- Contractual arrangements

- Management authorities

- Follower qualification requirements

A leader-follower approach may be initiated with documentation similar to that required for a Critical Design Review (CDR). These data would be augmented as the design matures. The technology transfer plan should define a schedule for the augmentation and delineate all required data, including the following:

- Engineering drawings and associated lists for the complete end item

- Electrical, hydraulic, and pneumatic schematics

- Logic diagrams

- Off-sheet parts lists

- Specification control drawings (SCDs)

- Interface control drawings

- System specification

- Development specification for prime and critical items

- Product fabrication specifications for prime and critical items

- Process and material specifications

- Purchase descriptions

- Test requirements and special test equipment drawings and specifications

- Packaging data sheets

- Data processing system requirements

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- Tapes for numerically controlled machining operations

- Approved ECPs

- Approved specification change notes (SCNs)

- Installation drawings

- Unique manufacturing data

- Special tooling drawings and specifications

- Quality assurance plans, procedures, and specifications

Similarly, the responsibilities of the leader in the areas of training, hardware provision, follower test equipment, and follower qualification should be specified. The follower's responsibilities in the areas of design reviews, hardware fabrication, test, and qualification should be defined also. The formal contractual agreements implementing these responsibilities should be noted.

The production competition plan also should identify a single individual within each organization responsible for the technology transfer program. The relationship of this individual to the rest of the organization should be presented. This will ensure that a single person, with clear management authority, is responsible for the leader-follower program.

11.5 FOLLOWER PRODUCTION QUALIFICATION

The main goal of a leader-follower program is to develop an alternative weapon supplier who can effectively

compete for a significant portion of the planned procurement. Thus, follower qualification involves both production qualification and demonstration of full rate production. Follower qualification tests can be performed by either the government or by the leader with government approval. Both of these approaches have been employed successfully on prior DoD leader-follower efforts.

If the follower is a subcontractor to the leader, the leader should conduct all production qualification tests and submit the results of the test to the program office. If the follower is a prime contractor, the government should conduct follower qualification. In both cases, the key to successful qualification is detailed consideration of qualification issues in the production competition plan.

The production competition plan should address all critical items associated with achieving follower qualification. These items include the following:

- Schedule
- Qualification responsibilities
- Configuration control
- Quality assurance
- Tooling
- Test equipment
- Suppliers

Many of these items involve extensive support from the leader, as discussed in Section 11.3.

The plan must include a schedule that presents all significant milestones related to specific technology transfer items, contractor technical exchanges, follower fabrication and assembly, test equipment availability, and follower production qualification. This schedule must be tied to the desired date for initiation of competitive awards. The program manager should note that this requires that economic analysis be performed to identify the preferred date.

Specific responsibilities for follower qualification should be defined also. The program manager may retain responsibility for qualification of the follower, if the follower is a prime contractor to the government. If the follower is a subcontractor to the leader, the system developer may conduct qualification testing subject to program office approval. The plan should specify responsibilities for on-line manufacturing test verification, cost schedule control system audit, subsystem testing qualification, end item qualification testing, production readiness reviews, and configuration audits. Also, the plan may specify responsibilities in the areas of design to cost audits, should cost reviews, and life cycle cost analyses.

The production competition plan should specify responsibilities in the area of configuration control. The system developer typically maintains configuration control up to CDR; however, the program office may assume configuration control earlier to avoid design changes that adversely affect competition. In addition, the plan should specify the use of compatible configuration control systems by both contractors. This may require adjusting the follower's configuration control system to be consistent with the leader's. The use of compatible systems enhances successful configuration audits and reduces management complexity when the program office assumes configuration control.

Quality assurance procedures and test equipment requirements are related directly to configuration control and should be described in detail. The follower should be qualified on test equipment identical to that employed by the leader, down to the lowest level of commonality. Thus, the leader must provide an identical set of test equipment to the follower.

The quality assurance programs of the two contractors should be similar. This may require the leader to assist the follower in the areas of process testing, subsystem and component evaluation, fault isolation, and supplier selection. The qualification plan should list the system developer's key suppliers and subcontractors, specifying those systems for which alternative suppliers may be desired. Responsibilities associated with the development of alternative suppliers should

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be highlighted. Similarly, subsystems for which a single
supplier is desired should be described.

11.6   LEADER-FOLLOWER IMPLEMENTATION

          This chapter has discussed several ways to implement a
leader-follower program. In undertaking a leader-follower
program, the program manager should undertake the following tasks:

- Determine the desired contractual arrangement with
  the follower, based on program office visibility
  and availability of program office personnel.

- Either select or approve the selection of a
  follower that possesses both engineering and
  production capabilities.

- Develop a production competition plan that clearly
  defines the technology to be transferred, the
  responsibilities of the contractors and the
  government, and the contractual arrangements.

- Ensure follower qualification by developing an
  integrated schedule and specifying test equipment
  and tooling requirements.

12.   LICENSING

Under a licensing approach to competitive production, the system developer, in exchange for a royalty fee, grants permission or license to another firm to produce an end item of proprietary interest to the developer.[1] In addition, the developer may provide technical assistance to the second source or licensee in exchange for engineering fees. The licensing technique is being employed currently in the cruise missiles engine program.

The program manager should note that this technique differs significantly from other competitive production techniques. The system developer, under the licensing concept, grants only limited data rights to the second source. The developer maintains proprietary interest in the data and retains design responsibility. Other techniques involve up-front government procurement of proprietary data. Thus, a licensing approach should be used only when the system developer refuses to grant the government unlimited data rights.

Given that unlimited data rights cannot be obtained, this chapter presents alternative actions to implement a licensing program. Key implementation issues discussed in this chapter include the following:

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[1] For a more detailed discussion of licensing, see Gregory A. Carter, "Directed Licensing: An Evaluation of a Proposed Technique for Reducing the Procurement Cost of Aircraft," The Rand Corporation, December 1974.

- Contractual arrangements
- Selection of a licensee
- Motivating the developer
- Technology transfer
- Licensee qualification

12.1 CONTRACTUAL ARRANGEMENTS

Two contractual methods to implement licensing have been employed on prior weapon system programs. The first technique, referred to as directed licensing, involves including an unpriced licensing option in the system developer's full-scale development (FSD) contract. The second technique involves contractor selection and qualification of the licensee.

Licensing Clause

One contractual method to implement a licensing program is to include a licensing provision in the system developer's FSD contract as an unpriced option. The clause would state that the system developer agrees to license another prod..:er and provide technical assistance to that producer to ensure production qualification. The second producer could be selected by either the government or the system developer with government approval. The clause could be exercised by the government following price negotiations conducted during FSD.

Using this approach the licensee would be contractually related to the system developer և through the license agreement. The government would award a prime contract to the licensee for production and fund the initial engineering services fees. The licensee would pay royalty fees to the system developer during production. Either the government or the system developer would perform qualification of the licensee.

The specific arrangements associated with this approach are normally delineated in a Memorandum of Agreement (MOA), signed by the developer, the licensee, and the government. The program manager should insist on an MOA to ensure that all parties understand their respective responsibilities.

By employing this method to implement a licensing program, the program manager can ensure the establishment of a second source while the program is in the competitive design phase. Competing design contractors could be presented with the licensing clause in the FSD Request for Proposal (RFP). The competing companies would be required to propose royalty fees, if any, while still under the pressures of design competition.

The program manager should note that this method establishes the licensee as a prime contractor to the government. Thus, the licensee views the government as the customer and is free to approach program office personnel with problems or innovative suggestions.

A problem with this approach is the use of an unpriced option and the requirement for subsequent negotiations when the developer is in a sole source position. Perhaps the program manager could overcome this limitation by requesting priced options in the FSD RFP, but this has been resisted by contractors in the past.

An Alternative Approach

Recent DoD experience with licensing has led to the evolution of another contractual method to implement a licensing program. The approach was developed in an ad hoc manner by developing contractors who were confronted with production competition. The contractors, in an attempt to limit the effects of competition, suggested licensing another source.

The program manager should recognize that this is not a recommended approach; however, it does present a unique contractual arrangement that may be useful. The approach involves establishment of the licensee as a subcontractor to the developer. The developer is responsible for selection of the licensee, technology transfer, and production qualification. The costs associated with these activities are paid by the government. The government retains the right to approve the selected licensee. In addition, the government maintains the option to acquire end items either directly from the licensee or through the system developer.

The program manager should recognize that this approach was suggested on prior programs by contractors who were faced with competition. In order to apply a similar approach, the program manager must secure the agreement of the system developer. This can be obtained via an option in the developer's FSD contract.

This approach reduces the administrative burden on the program office. Furthermore, it enhances the establishment of a cooperative licensor-licensee arrangement by enabling the licensor to select the licensee. The approach also provides the potential for incentive clauses to be included in the developer's prime contract to motivate developer activities in establishing the licensee.

This approach also presents several disadvantages. By establishing the licensee as a subcontractor to the developer, the licensee may view the developer as the customer. Consequently, the licensee may be reluctant to discuss technology transfer problems with the government, thus enabling the system developer to delay qualification of the licensee.

Another potential problem is the lack of government control over the selection of the second source. The system developer may be able to select a second source that would be incapable of true competition. In one cruise missile engine

competition, the prime's selection of a noncapable second source
was rejected based upon a government facilities inspection.[2]

Selection of a Method

The particular contractual method used to implement a
licensing arrangement must be determined by the program manager
based upon program characteristics. In reaching such a
determination, the program manager should recognize the risks
associated with establishing the licensee as a subcontractor to
the system developer.

12.2   SELECTION OF A LICENSEE

The licensee can be selected by either the government
or the system developer. Each method has associated advantages
and disadvantages. Whatever method is used, the program manager
must ensure that the source selection process leads to the
selection of a capable licensee. Such a licensee would possess
demonstrated engineering and manufacturing capabilities, as well
as a competitive cost structure.

To ensure the selection of a capable licensee, the
program manager must ensure that adequate technical data is
provided to potential licensees to enable them to prepare cost

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[2]George Francis Sparks, "Direct Licensing in Major
Weapon System Acquisition," Naval Postgraduate School, September
1980.

proposals. In addition, the program manager should conduct
on-site surveys, and request documentation of experience. Under
a licensing approach, the provision of adequate technical data is
a difficult area. By using a licensing method, the program
manager is recognizing the proprietary data rights of the system
developer. Thus, these data cannot be included in the licensee
RFP. The adverse effects of this problem can be limited by
including the government technical data package in the licensee
RFP. The existence of proprietary data should be noted in the
RFP, so that qualified bidders are aware of the problem.

Program Office Selection of the Licensee

To solicit and select a licensee, the program manager
must undertake the following:

- Assemble adequate technical documentation.
- Prepare and release an RFP.
- Conduct on-site reviews and audits.
- Evaluate the proposals and reviews.
- Select a licensee and negotiate an award.
- Negotiate a license agreement that is acceptable
  to the licensee and licensor.

These activities require considerable program office
administrative effort; however, they also reduce the risk of
selecting a noncapable licensee. Furthermore, program office
selection of the licensee establishes a direct relationship
between the government and the licensee. The direct relationship

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enhances technical exchange and clearly identifies the government
as the licensee's customer. In addition, the direct relationship
improves the program office's ability to monitor the progress of
the licensee in technology transfer and production qualification.

Program office selection of the licensee has many
advantages; however, it also presents a risk of selecting a
licensee that is unacceptable to the system developer. This may
be due to bitter rivalries in other areas or a desire on the part
of the licensor not to reveal certain aspects of the technology
to certain competitors. Forcing a license agreement under such
circumstances would invite slow technology transfer and further
complications.

Developer Selection of the Licensee

The system developer could perform the selection tasks
and select a licensee, subject to program office approval. This
approach limits program office administrative effort and enhances
the selection of a licensee acceptable to the system developer.
Furthermore, program office liability related to licensee
performance is limited.

These advantages must be weighed against the
disadvantages associated with developer selection of the
licensee. The approach limits government visibility into the
licensee source selection process and may limit communication
between the government and the licensee. In addition, this

approach requires that the licensee be a subcontractor to the developer through production qualification. Subsequent production would be performed under a prime contract to the government. To provide incentives to the developer during technology transfer and production qualification, the program manager should specify technology transfer and qualification milestones in the developer's contract and tie progress payments to those milestones.

Selecting the Licensee

Both methods for selecting a licensee have been used on prior DoD licensing ograms. The key difference between the two approaches is the risk and complexity associated with de eloper selection of the licensee. Clear recognition of these risks may enable the program manager to structure a rigorous license arrangement that avoids the problems of developer selection. The key point in either selection method is that the program manager must retain final authority over licensee selection. Following this, direct communication with the licensee must be maintained.

12.3   MOTIVATING THE DEVELOPER

One advantage of the licensing technique is that it is tied to the developer's FSD contract. This tie can be exploited by the program manager to motivate the developer to assist the licensee in a timely manner. The program manager should consider positive and negative incentives.

Positive incentives, such as award fees, can be directly tied to the FSD contract. Effective negative incentives have also been used on prior programs. For example, the developer can be required to subcontract a portion of the initial production buy to the licensee, but still be liable for timely delivery of the total buy. The program manager must recognize that use of any incentive requires that the developer's responsibilities be clearly defined. In addition, responsibilities must be reflected in a specific milestone schedule.

12.4 TECHNOLOGY TRANSFER

Technology transfer under a licensing approach is achieved by the license agreement, which should specify the following:

- Limited rights to the developer's proprietary data
- Data items to be provided to the licensee
- Technical support to be provided to the licensee
- Milestone schedules

The data items to be provided to the licensee should include all design and process information necessary to manufacture, test, and deliver the end item. These may include the following:

- Engineering drawings and associated lists for the complete end item
- Electrical, hydraulic, and pneumatic schematics
- Logic diagrams
- Off-sheet parts lists

- Specification control drawings (SCDs)

- Interface control drawings

- Development specification for prime and critical items

- Product fabrication specifications for prime and critical items

- Process and material specifications

- Purchase descriptions

- Test requirements and special test equipment drawings and specifications

- Packaging data sheets

- Data processing system requirements

- Tapes for numerically controlled machining operations

- Approved E ?s

- Approved specification change notices (SCNs)

- Installation drawings

- Unique manufacturing data

- Special tooling drawings and specifications

- Quality assurance plans, procedures, and specifications

The proprietary data included in these items should be marked clearly.

The license agreement also should specify the technical support that is to be provided by the developer. This support may include in-process reviews, supplier qualification, provision of subassemblies and test articles, bench tests, in-plant assistance, design reviews, and production qualification assistance. The support should be provided at a level necessary

to ensure production qualification of the licensee.

Requirements for data delivery and technical support should be reflected in a milestone schedule. The schedule should work back from the desired licensee qualification date. Potential milestones include the following:

- Initial management meetings
- Design briefings and engineering exchanges
- Delivery of data items
- Subassembly delivery and inspection
- End item disassembly, inspection, and reassembly by the licensee
- Subassembly fabrication and test
- Subassembly integration and test
- End item fabrication
- Production qualification

The exact activities related to each of these milestones would be defined by program characteristics. The key is to identify relevant milestones and tie those milestones to the developer's contractually provided incentives. The program manager then has a useful tool to monitor progress and to motivate the developer.

12.5   LICENSEE QUALIFICATION

The technology transfer milestones should be extended to include production qualification of the licensee. Similarly, incentives applied to the developer's contract should also extend to licensee production qualification.

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Qualification can be certified either by the government or by the developer with government approval. Neither approach has a distinct advantage over the other, as long as the qualification process is rigorous.

The program manager can enhance qualification of the licensee and configuration control by requiring the licensee to use test equipment identical to that used by the developer. Similarly, the licensee should apply quality assurance and configuration control procedures identical to those employed by the licensor. One advantage of licensing is that the license agreement typically includes this requirement.

The program manager also should consider production rate demonstration as part of the qualification process. Such a demonstration is a necessary condition for competitive production of the end item. To ensure rate capability, the program manager may direct a larger buy to the licensee following initial qualification. Successful delivery of this buy would indicate true qualification of the licensee.

12.6   LICENSING IMPLEMENTATION

This chapter has presented alternative methods that could be used by the program manager to implement a licensing approach to competitive production. The fundamental difference between licensing and other technology transfer techniques is

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that the developer retains the right to proprietary data and system responsibility. This p.aces special emphasis on careful, early planning. Specifically, the program manager should undertake the following:

- Ensure that the licensing clause on the developer's contract adequately describes the developer's responsibilities.

- Delineate the responsibilities of the developer, the licensee, and the government in a Memorandum of Agreement.

- Develop a milestone schedule of technology transfer and production qualification activities.

- Employ negative and positive incentives to motivate the developer to assist the licensee.

13.   CONTRACTOR TEAMING

The contractor teaming approach to competitive production is a complicated endeavor used to ensure adequate transfer of complex weapon system technology. The teaming approach has been employed recently by the ASPJ and the JVX programs.

The project manager must recognize that effective use of contractor teaming requires formation of teams during the early development phases of the program. At the latest, contractor teams must be formed prior to submittal of full-scale development (FSD) proposals. Thus, if teaming is to be employed, the program manager must commit to production competition much earlier than is required when employing other technology transfer techniques.

Because each member of the team develops specific portions of the equipment and transfers that technology to the other team member, both team contractors are qualified concurrently for production of the entire end item. Following qualification, the team is split for competitive production.[1] These characteristics present unique implementation issues in the following areas:

- Contractual relationships

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[1] For a more detailed discussion of contractor teaming, see Joseph Murray Ruppert and Steven Craig Sterrett, "Competitive Contractor Teaming Second Sourcing Strategy as Implemented by the Airborne Self Protection Jammer Program Office," Naval Postgraduate School, December 1983.

- Team member selection

- Technology transfer

- Production qualification

- Configuration control

13.1   CONTRACTUAL RELATIONSHIPS

A contractor teaming approach can be implemented
contractually in two ways:

- A prime contract with one of the team members
  would specify award of a subcontract to the other
  team member.

- The team members could form a separate entity or
  joint venture, to which the government would award
  a prime contract.

Both methods have associated advantages and disadvantages. The
key point of interest to the program manager is that the program
office awards and monitors a single development contract under
either method. The methods differ as to the agreements between
the team members and the associated responsibilities implied by
those agreements.

Subcontract Method

As mentioned, the contractor teaming approach could be
implemented contractually by requiring that the prime contract
with one of the contractors specify award of a subcontract to the
other team member. The program manager must recognize that this
method requires considerable program office administrative effort

to ensure the integrity of the team approach. This effort
includes the following:

- Solicitation of the teaming approach in the
  Request for Proposal (RFP), including a contingent
  subcontract arrangement that clearly specifies the
  responsibilities of the team members.

- Evaluation of the proposals with special emphasis
  on the subcontract agreement. Site surveys,
  preaward audits, and detailed negotiations may be
  required to ensure the formation of a viable team.

- Award and negotiation of the contract.

The detailed preaward activities are required to ensure
successful implementation of the subcontract method. The program
manager should note that under this method the program office has
no direct access to the subcontractor following contract award.
Thus, the program manager must ensure the contractor team is
viable prior to award of the contract.

In evaluating the proposals, the program office must
ensure that both contractors are capable of producing the entire
system. Demonstrated production capability on prior similar
programs should be a key source selection criterion. The program
office should guard against the development of teams composed of
complementary contractors. In a subcontract arrangement, the
contractors may remain merely complementary, as a result of
inadequate technology transfer, and thus present the program
manager with a single source supplier.

The key advantage of the subcontract method is that it
can be implemented using existing contract vehicles. Special

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clauses may be required; however, there is no need to develop special teaming agreements. In addition, since one of the team members is a prime contractor, that firm assumes clear responsibility for the development effort.

This advantage also can prove to be a disadvantage, in that the prime contractor may be able to exercise considerable leverage over the subcontractor. Rather than a true team, the arrangement may lead to a classical prime-subcontractor relationship. Furthermore, the program office has no direct contractual link to the other team member. If problems arise, the program manager must work through the prime contractor. Finally, if the prime contractor is lax in transferring technology, the subcontracted team member has few options. As a subcontractor, the team member cannot force the prime contractor to cooperate.

Joint Venture Method

Another method for implementing contractor teaming is through the establishment of a joint venture. The joint venture would be a new corporate entity, supported and staffed equally by both team members. To implement a joint venture, the following activities must be undertaken:

- The program office must release an RFP, specifying a teaming approach and a joint venture method.

- Potential contractors must identify and form teams.

- The contractors must enter into a preliminary Teaming Agreement to enable efficient preparation of the proposals.

- The proposals must be prepared and submitted in accordance with a joint venture approach.

- The program office must evaluate the proposals and select a winner.

- The winning team must enter into a formal Teaming Agreement establishing the joint venture.

- The contract must be awarded to the joint venture.

The joint venture method places much of the administrative burden on the contractors, thus limiting program office administrative involvement. In evaluating the proposals, the program office must ensure the contractor team will be capable of competition; however, the program office is not required to specify the details of the contractors' arrangements.

The joint venture method also establishes the two contractors as equal team partners. Each must rely on the other team member for critical subsystems and deliveries. Thus, contractor cooperation is enhanced and many of the potential problems associated with the subcontract method are avoided.

The joint venture method also removes much of the potential technology transfer burden from the program office. If one of the team members is lax in transferring technology, the other member can exercise considerable leverage. This is possible only because of the balanced interdependence of the two contractors.

A joint venture also presents several disadvantages. This complex method of establishing a contractor team requires that a new entity be formed, that team members be identified, that personnel be assigned, and that accounting and administrative procedures be established. These activities place a heavy burden on the contractors and require continuing contractor cooperation.

Another potential disadvantage of a joint venture is that while equal partners may be established, they may remain geographically separated. Thus, the program office may be faced with three entities (a joint venture and two contractors), complicating program management. This is in contrast to the subcontract method that clearly involves only one prime contract with the government.

Selecting a Method

The joint venture method presents several advantages over the subcontract method of establishing contractor teams. Unfortunately, the program manager cannot force the contractors to form joint ventures. The preference for a joint venture can be stated in the RFP; however, it is unlikely that the program office can force a joint venture method. Thus, the program manager may have to accept a subcontract method. In such a circumstance, detailed contractual agreements must be reached prior to award of the contract.

13.2   TEAM MEMBER SELECTION

The selection of team members and the formation of teams must be accomplished by the contractors. The program office cannot direct the establishment of a particular team nor can it identify a preferred contractor to team with. Such direction would place considerable risk on the program office.

The program office can influence the selection of team members by insisting in the RFP that both team members have demonstrated production capability with similar end items. The team's production strengths should be evaluated in the source selection process. Complementary teams could be judged as nonresponsive to the RFP, if both team members had not produced all-up end items. In this manner the program manager could enhance the development of teams capable of future competition, while not directing the composition of any particular team.

13.3   TECHNOLOGY TRANSFER

Technology transfer under a teaming approach to competitive production is achieved through direct contractor exchange. The exchange should be phased to ensure concurrent production qualification of the contractors. Specific activities may include the following:

- Exchange of subsystems and data for inspection, disassembly, and reassembly by the other team member

- Fabrication and test of several joint articles

- Simultaneous exchange of technical data and provision of engineering support

- Fabrication and test of subsystems by the other team member

- Fabrication and test of independent all-up end items

These activities could form the key milestones on a technology transfer schedule. The specifics of the schedule would be determined by program specific circumstances and manufacturing methods.

The development schedule of critical subsystems may preclude simultaneous exchange of technical data. In such a circumstance, it is particularly important to identify data delivery dates. The criticality of this schedule is due to the loss of leverage suffered by the team member who has already delivered the data associated with developed subsystems.

13.4   PRODUCTION QUALIFICATION

Under a teaming approach, the government should conduct concurrent production qualification of the two firms. Both contractors should be qualified on identical test equipment; thus the program manager must anticipate duplicative sets of test equipment down to the lowest level. Furthermore, the program office must conduct in-process reviews, configuration audits, cost audits and analyses, cost schedule control system verifications, vendor analyses, and end item qualification at two facilities. These activities may require assistance from other

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government agencies. In qualifying the team members, the program manager should anticipate the complexity of the task and identify additional support, if required.

The program manager also should consider maintaining the contractor team through initial production, to ensure production rate capabilities. The team would be awarded a production contract which specified a 50/50 split between the two contractors. Following successful deliveries of both contractors' end items, the team could be split for competitive awards.

13.5   CONFIGURATION CONTROL

Cnce the team is split for competitive production, the program manager is faced with the issue of who maintains configuration control and design responsibilities. This could be a significant problem if the end item must be integrated with several other systems.

One method to limit this potential problem is for the program office to assume configuration control following initial production. The program manager could establish a configuration control board that included both contractors. The board would exercise approval authority over both Class I and Class II change proposals from both contractors.

This method will enhance strict configuration maintenance; however, it may also discourage innovative design changes that reduce cost. A contractor may be less likely to suggest cost reducing proposals if they must be approved by the firm's competitor. The program manager should anticipate this problem and provide sufficient design flexibility to encourage cost reducing changes, while maintaining adequate configuration control. This can be accomplished by specifying commonality of the equipment at or above the throwaway level. Design changes below the throwaway level could be undertaken without the need for approval by the joint configuration control board.

13.6   CONTRACTOR TEAMING IMPLEMENTATION

As discussed, the contractor teaming approach to production competition is a complex endeavor, requiring considerable administrative effort and planning. In implementing a teaming approach the program manager should undertake the following:

- Include the team concept in the program's initial acquisition strategy and in the development RFPs, stating a preference for joint venture arrangements.

- Allow the contractors total latitude in developing teams and identifying contractual methods.

- Ensure that the source selection criteria measure the demonstrated production experience of the team members.

- Establish a milestone schedule for technology transfer.

- Concurrently qualify both producers for production, using identical test equipment.

- Maintain the team through initial production to ensure production rate capability.

- Establish a configuration control board that is chaired by the program office (as configuration control agent) and that includes both contractors.

PART FOUR

EXECUTION OF CONTINUOUS
PRODUCTION COMPETITION

14.   PRODUCTION AWARDS

Following technology transfer and second source qualification, one of the key issues facing the program manager is the allocation of production quantities during the split buy, competitive phase of production. Typically, in a competitive production program, the low bidder is awarded the major portion of the annual buy, but the high bidder is assured award of at least part of the buy. This guarantee, resulting from the desire to maintain two production sources, may diminish competitive pressures.

Several methods of production quantity allocation have been suggested and employed successfully. The following methods are discussed below with reference to historical experience:

- Minimum Total Cost Rule
- Solinsky Rule
- Pelzer Rule
- PRO Concept

In addition, the use of multiyear awards and buy out are discussed.

The adaptation of one of the award methods to a particular program should reflect program circumstances and goals. The program manager should ensure that the method employed is understandable and that it enhances the competitive environment by limiting the potential for contractor gaming. The

first consideration in developing an award split methodology involves the use of a minimum sustaining rate.

14.1   MINIMUM SUSTAINING RATE

The use of a minimum sustaining rate involves the guarantee of a fixed portion of the annual production buy to the higher bidding contractor. This rate is normally the lowest production rate required to maintain the contractor in production. Such a minimum may be as low as 10 percent of the buy.

Splitting the production buy ensures the viability of future competition. The split award also involves an apparent short-term loss in efficiency, in that award of the entire year's production buy to the low bid contractor could yield a lower procurement cost for the given year, compared to a split buy. On the other hand, the loss of a year's production experience would reduce the capability of the higher priced contractor to compete for future awards. This could result in establishing the winner of the initial competition as a sole source supplier, subjecting the government to potential monopoly pricing.

Several authors have contended that a guaranteed minimum rate diminishes the competitive environment.[1] It has

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[1] Jay L. Pelzer, "Proposed Allocation Technique for a Two-Contractor Procurement," Air Force Institute of Technology, May 1979.

been suggested that contractors may overprice the lower
quantities, thus attaining excess profits. Normally this
potential problem is overcome during negotiations with the high
bid contractor; however, if a minimum rate has been guaranteed,
the program manager has lost some negotiating leverage. Also, it
is argued, contractors may be content with the lower quantity and
thus not bid aggressively for the higher portion.

These potential problems have been overcome on prior
programs that employed sustaining rates successfully. Program
managers and contracting officers have developed specific
techniques to take advantage of the competitive environment and
to limit potential contractor gaming.

14.   THE MINIMUM TOTAL COST RULE

The minimum total cost rule involves solicitation of
contractor prices for various portions of the total quantity buy.
For example, lot prices for 40, 45, 50, 55, and 60 percent of the
buy may be requested. The contractors' corresponding competing
bids are summed for a total lot cost. The least cost combination
determines the award percentages. An example of this technique
is shown in Table 14.2-1. The example is based upon an Army
Missile Command (MICOM) program, involving an annual buy of
20,000 missiles.[2]

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[2]J. A. Muller, "Competitive Missile Procurement,"
Army Logistician, Volume 4, Number 6, November-December 1972.

Table 14.2-1

Example Minimum Total Cost Rule

Contractor A		Contractor B		
Percent of Buy	Bid Lot Cost $M	Percent of Buy	Bid Lot Cost $M	Total Cost in Millions of Dollars
40	52.2	60	76.8	129.0
45	58.5	55	70.8	129.3
50	63.9	50	64.5	128.4
55	69.3	45	58.2	127.5
60	72.0	40	51.6	123.6

As shown in Table 14.2-1, the minimum total cost combination occurs when contractor A receives 60 percent of the award and contractor B receives 40 percent of the award.

The minimum total cost rule is subject to potential contractor gaming, in that the contractors are presented with the opportunity to raise their bids on the smaller quantities. Such manipulation may result in award of the larger portion of

production to the high cost bidder.[3] This can be demonstrated through a numeric example based upon the example shown in Table 14.2-1. If contractor B increases its lower quantity bids, the larger share of production would be awarded to contractor B. This is shown in Table 14.2-2. Contractor B's bids were increased by 5 percent for the 50 percent bid, 10 percent for the 45 percent bid, and 20 percent for the 40 percent bid. As shown in Table 14.2-2, the bid series does not appear unreasonable.

Table 14.2-2

Example Minimum Total Cost Rule

Contractor A		Contractor B		Total Cost in Millions of Dollars
Percent of Buy	Bid Lot Cost $M	Percent of Buy	Bid Lot Cost $M	
40	52.2	60	76.8	129.0
45	58.5	55	70.8	129.3
50	63.9	50	67.7	131.6
55	69.3	45	64.0	133.3
60	72.0	40	61.9	133.9

[3] David W. Elam and Paul Martin, "Requirements for Successful Implementation of a Competitive Dual Source Production Strategy," The Analytic Sciences Corporation, October 1980.

One method to limit potential bid manipulation is to conduct should cost audits of both contractors prior to solicitation. These special should cost audits enable the government to establish reasonable bounds for the contractors' bids. If the actual bid prices appear unreasonable, detailed supporting documentation can be requested. This procedure was employed by MICOM on two missile programs, TOW and SHILLELAGH.

14.3   SOLINSKY RULE

Another quantity allocation technique developed by the Army involves solicitation of contractor bids for various quantities and calculation of midpoint bid prices. These prices are used as inputs to an arc-tangent formulation that determines the production split. This method is referred to as the Solinsky rule.[4]

The Solinsky rule was developed to enhance aggressive bidding by awarding percentage shares of production, based upon the difference in bid prices for a midrange quantity. If the differential between the two contractors' bids is large, the percentage share differential is large. Similarly, if the bid differential is small, the percentage share differential is

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[4]Kenneth S. Solinsky, "A Procurement Strategy for Achieving Effective Competition While Preserving an Industrial Mobilization Base," U.S. Army Electronics R&D Command, Night Vision and Electro-Optics Laboratory (undated).

small. The bid differential is calculated as shown in equation 14.3-1.

$$\frac{\text{Company B price} - \text{Company A price}}{\text{Company B price} + \text{Company A price}} \qquad (14.3\text{-}1)$$

The bid differential is calculated for the midrange quantity only. As an example, if the total buy equals 10,000 units and bids were solicited for ranges of 2000-4000, 4000-6000, and 6000-8000 units, the bid differential (X) would be calculated for the 4000-6000 range only.

The percentage share of production is calculated according to an arc-tangent formulation. An example formulation is presented in Figure 14.3-1.
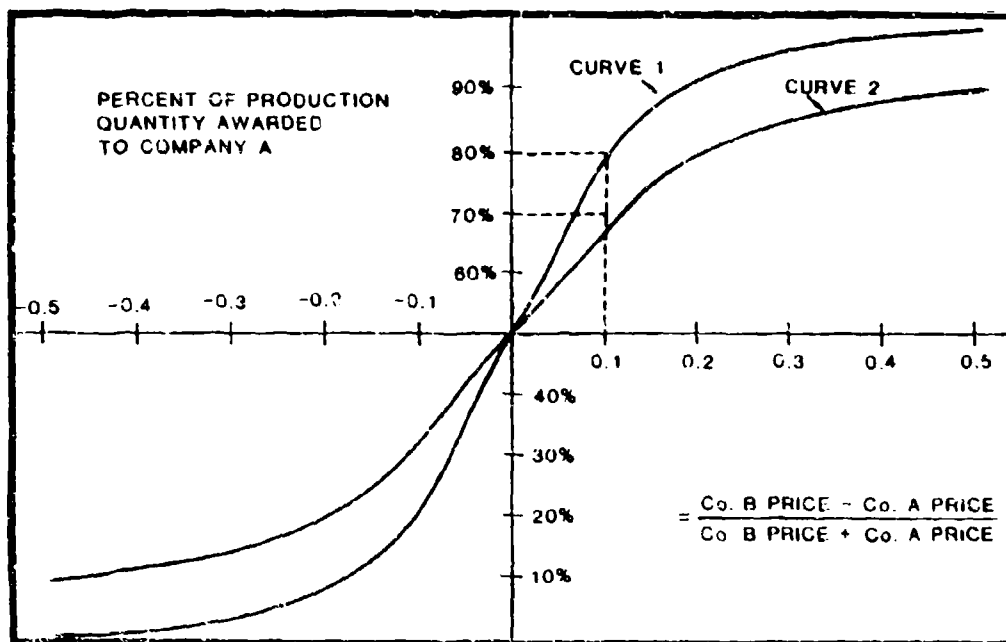
Figure 14.3-1   Example Solinsky Rule

As shown in Figure 14.3-1, the Solinsky rule can be portrayed as a four-quadrant diagram. The ratio of company B's bid to company A's bid is presented along the X-axis. The percent of the production buy awarded to company A is shown along the Y axis. A family of arc-tangent curves, similar to curve 1 and curve 2 in Figure 14.3-1, can be generated by the program office by varying the constants assoc..ated with the arc-tangent function. As shown, the possible award outcome can vary significantly depending upon the particular arc-tangent function that is chosen. A particular function would be selected by the program office prior to releasing the RFP.

The Solinsky rule limits the potential problems associated with the minimum cost rule; however, it also is susceptible to contractor gaming. This is due to its reliance on a single midrange price. The method presents an incentive to the contractors to minimize the midrange price and to inflate prices outside of the midrange. This is particularly attractive to the contractors, because the actual award probably will be outside of the midrange. A profit maximizing firm may price the outer range quantities up to the point where marginal profits gained from a higher price are equal to the marginal profits lost from a lower award quantity.[5]

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[5]Charles H. Smith, "On Defense Production Contracting with Multiple Sources and Limited Competition," APRO Research Paper P-7, March 1982.

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The Solinsky rule was used successfully by the U.S. Army Electronics Command (ECOM) Night Vision Laboratory during the competitive production of the AN/PVS-5A Night Vision Goggles. The application included a minimum award of 10 percent of the 10,284 unit total procurement. Prices were solicited from both contractors for seven ranges, beginning with 2-2000 units up to 12000-14000 units. The contractors were given explicit details of the award methodology, except for the exact form of the arc-tangent function. This was done to limit contractor gaming. In addition, ECOM reserved the right to split the award at the midrange and to audit the contractors' bids. The audits were conducted and production contracts negotiated. The production contract totaled $74 million, a $7 million cost savings compared to budget estimates.

14.4   PELZER RULE

The effect of price competition on product quality is an area of great concern. It has been argued that price competition forces contractors to trade off cost and quality, often leading to reduced system performance. Pelzer has developed an allocation technique that reduces this risk, by incorporating quality and other relevant factors into the award formulation.[6]

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[6]Jay L. Pelzer, "Proposed Allocation Technique for a Two-Contractor Procurement," Air Force Institute of Technology, May 1979.

The Pelzer technique assumes that the system developer will enjoy considerable production experience relative to the second producer. Thus, the second producer could not be price competitive. To adjust for this, Pelzer develops an index weighting system which reflects relative price decreases over a three-year period.

The technique involves requesting bids from both contractors for various production quantities. The bid prices are then fit to a quadratic equation to reflect the effect of production rate variations on unit costs. Average unit costs are calculated for both contractors and then input into the selection formula.

The selection formula includes other factors such as equipment performance and timeliness of delivery, measured as achieved performance versus desired. The factors are weighted according to their relative importance. Mathematically, the other competitive factors are calculated as shown in equation 14.4-1.

$$F_X = \left[1 + \left(W_X \left(1 - \frac{R_X}{S_X} \right) \right) \right] \qquad (14.4-1)$$

where:

W_X = the weight assigned to factor X

R_X = the achieved contractor performance for factor X

S_X = the specified standard for factor X

The Pelzer technique for calculating the annual competitive index can be expressed as shown in equation 14.4-2.

$$I_a = (P_a) (F_1) (F_2) (F_3) \ldots (F_n) \qquad (14.4-2)$$

where:

I_a = the annual total competitive index for contractor A

P_a = the average unit line price bid for contractor A

F_1 through F_n are other competitive factors.

The annual index is used to calculate an overall competitive index for the contractor that reflects the contractor's competitive behavior in the two prior years. Mathematically the index is calculated as shown in equation 14.4-3.

$$\text{Overall Index} = I_{a,n} \times \frac{I_{a,n}}{I_{a,n-1}} \times \frac{I_{a,n-1}}{I_{a,n-2}} \qquad (14.4-3)$$

The ratio of the two contractors' overall competitive indices is used to determine the production quantity split.

The Pelzer approach presents several advantages over prior allocation techniques. Contractor gaming is limited by the use of a three-year, moving-average index. In addition, the inclusion of factors other than price reduces the risk of late deliveries or poor performance.

The Pelzer approach is relatively complex; however, it is not immune to contractor bid manipulation. Pelzer describes several ways in which the technique can be gamed. For example,

if a contractor perceives he can win a high percentage of the award by bidding a certain average unit cost, he may manipulate his bids. The lower percent bids could be reduced and the higher percent bids increased while maintaining the same average bid. Thus, if awarded the higher quantity, the contractor could obtain excess profit. Despite these potential problems, the Pelzer approach was employed successfully in the procurement of the GAU-8 30-millimeter ammunition.

14.5 THE PRO CONCEPT

The Profit Related to Offers (PRO) Concept was developed by the Navy Strategic Systems Project Office (SSPO) for use during competitive production of the Trident MK-5 Inertial Measurement Unit and Electronics Assembly. This approach differs from other allocation techniques in that both competing contractors receive 50 percent of the production award.[7] Profit margin is adjusted based upon the contractors' bids.

The PRO Concept was devised to avoid the potential low quantity bidding games associated with other allocation techniques. In addition, the concept stresses product quality and performance, rather than merely bid price. This was a key

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[7]This discussion is based upon materials provided by John Dunagan of SSPO to J. W. Drinnon on 7 July 1983. This material included: K. V. Fleming, "The PRO Concept," February 1980.

concern of the SSPO, who developed competitive sources to ensure
an adequate supply of strategically critical subsystems.

The concept can be summarized as the following six
steps:

1. The project office determines a competitive price
    range for the equipment.

2. Both contractors are asked to submit target cost
    bids for 50 percent of the annual buy.

3. If the bids are within the competitive range, the
    low cost bidder is the winning contractor and is
    awarded a fixed price incentive contract at the
    proposed target cost. The contract includes a
    predetermined target profit and a predetermined
    share line.

4. The high cost bidder is awarded a fixed price
    incentive contract at the bid target cost if the
    bid is within 25 percent of the winning
    contractor's bid. A target profit is determined
    based upon the dispersion of the two bids.

5. If the high bidder's proposed target cost is
    greater than 25 percent of the winning
    contractor's bid, target cost is determined by
    negotiation. Target profit is determined by
    weighted profit guidelines.

6. Share line relationships between target cost and
    contract ceiling are determined by a random
    procedure, to deter contractor gaming.

As discussed in Step 4, the high bid contractor's
target profit is determined based upon the dispersion of the
bids. An example profit formula is presented in equation 14.5-1.

$$P_L = \begin{cases} 0.140\, C_W - 0.3\,(C_L - C_W) & \text{if } 1.00 < C_L/C_W \leq 1.25 \\ 0.065\, C_W - 0.075\,(C_L - C_W) & \text{if } 1.25 < C_L/C_W \leq 1.50 \\ .04625\, C_W & \text{if } 1.50 < C_L/C_W \end{cases} \qquad (14.5\text{-}1)$$

Where:

C_L = Bid cost of the losing contractor

C_W = Bid cost of the winning contractor

P_L = Target profit of the losing contractor

As shown by equation 14.5-1, there are significant profit penalties for the losing contractor if his bid is a great deal higher than the winner's bid. On the other hand, if the bids are close, the losing contractor receives a target profit that approaches that of the winner. This formulation enhances competitive bidding by motivating both contractors to bid their best estimates initially. Furthermore, if the losing contractor's bid is 25 percent greater than the winner's bid, target cost is negotiated and the share line is adjusted.

The PRO Concept was developed to avoid the problems associated with other allocation techniques that base quantity splits strictly on cost. It presents the additional advantage of maintaining both contractors in competitive positions for the following year's buys, due to the equal quantity split. The PRO Concept has evolved over the last four years, with continual adjustments made by SSPO to deter contractor gaming. In addition, the profit formulation for the losing contractor is

adjusted annually to avoid the potential problems of bidding to lose.

14.6   MULTIYEAR AWARDS

Often the use of multiyear awards is viewed as an alternative to competitive production. Rather than adopt this view, the program manager should consider competitive production and multiyear procurements as complementary. Multiyear awards have been employed on several prior competitive production programs, such as GAU-8 30-millimeter ammunition and the Army Night Vision Goggles. In addition, multiyear buys are planned for AMRAAM. These programs involved split buys in which both contractors were awarded multiyear contracts.

The benefits of multiyear awards and production competition can be obtained if sufficient attention is given to the duration of the multiyear award. Extended awards may facilitate contractor planning and supplier purchases, thus leading to reduced costs. Extended awards also tie the second producer to the smaller production quantity for a longer period, possibly adversely affecting the firm's ability to price competitively for future awards. Thus, the program manager must weigh the frequency of competition against extended multiyear awards. In addition, potential for product innovation and design growth should be considered when determining the length of multiyear awards.

14.7   BUY OUT

MICOM has combined multiyear techniques with production competition by employing buy outs at the end of the production run.   A program buy out typically occurs after a series of annual competitions and involves the award of all remaining production to the winner of a final competition, even if the remaining items are to be produced over several years.

The buy out enables the program manager to obtain the benefits of competition as well as the efficiencies of a large production run, if the buy out is well planned.   For example, the program manager should be sure the program is at the end of its production run.   If production is extended beyond the buy out, the losing contractor will not be involved in the program, and the program manager will be in a sole source situation.

Configuration control responsibilities following the buy out should also be considered.   If the system developer loses the buy out, the second source may assume design responsibilities or the system developer may retain configuration responsibilities.   The latter alternative presents the awkward situation in which a contractor who is not producing an item maintains configuration control.

Also, a buy out program can backfire on a program manager whose system design is not firm.   Future ECPs can provide

the winning contractor with opportunities to gain excess profits from his monopoly position.

14.8   PROGRAM CONSIDERATIONS

In addition to the buy out issue, other program considerations must be assessed relative to the award methodology. For example, product improvement may lead to the production of two different configurations. The award methodology would have to reflect the presence of alternative designs. Similarly, other considerations may play a greater role than cost in source selection. Factors such as performance, reliability, or schedule may be key program concerns. These concerns must be adequately represented in the award methodology.

The meth ologies for competitive production allocation have developed in sophistication and complexity. The program manager must adapt the various methods to particular program requirements. The methodology selected should be well understood by the government and contractors.

15.   LOGISTIC SUPPORT

One of the potential costs attributed to competitive production results from the complexities which may be introduced into the logistic support of the weapon system. Because deployment of two configurations may lead to additional spares, support equipment, technical data, and training requirements, the program manager should consider logistics issues early in planning for production competition. Many of the problems encountered on prior programs can be avoided by giving adequate consideration to configuration management and the system maintenance concept.

15.1   CONFIGURATION MANAGEMENT

Rigorous configuration management can decrease the potential adverse logistics effects of competitive production. To achieve adequate configuration control the program manager should do planning in four problem areas:

- Designation of the configuration control agent
- Processing of Class II ECPs
- Design of configuration management systems
- Specification of test equipment

Chapter Five discussed the importance of these matters in achieving a successful production competition program. This section presents the advantages and disadvantages of alternative methods of handling these potential problems.

The role of configuration control agent can be performed either by the system developer or by the program office. Normally, the system developer will maintain configuration control up to Critical Design Review (CDR). Following CDR the program office can assume configuration control responsibilities or delegate this responsibility to the system developer for a finite period. The government must at some point during production assume configuration control.

There are several advantages associated with contractor configuration management through initial production. Producibility changes introduced during initial production can conveniently be incorporated into the data package by the contractor. Thus, when a stable design is achieved, the current configuration documentation can be delivered to the government. This reduces program office personnel requirements and avoids the generation of outdated technical documentation.

In a competitive production program, configuration control by the system developer also presents potential disadvantages. As the control agent, the developer can approve or disapprove engineering changes proposed by the second source. In addition, the developer can implement design changes without consideration of their impact on the second producer's costs. These factors may have an adverse effect on the ability of the second source to produce the system efficiently in a competitive environment.

Government assumption of configuration control responsibilities avoids these potential problems; however, a greater management burden is placed on the program office. In addition to an increased engineering staff, the program office may require increased engineering support from other DoD activities. The program manager should anticipate these costs when considering early government configuration control.

This increased staff may enable the program office to exercise a great deal of authority on the configuration control board (CCB). It is suggested that the board include program office personnel and personnel from both contractors. This decreases the potential for the introduction of changes that may have an adverse effect on one of the producers.

Government configuration control is particularly advantageous when considering Class II ECPs. There are two types of ECPs:

- Class I--a noninterchangeable alteration in equipment which may have an impact on the cost of a system.

- Class II--a change where altered assemblies or components are capable of being freely exchanged with earlier designs.

Class I ECPs are normally reviewed by the CCB, which evaluates the implications of approval and determines implementation. Class II ECPs are usually evaluated by a resident government representative who approves the

classification. The changes are then initiated by the contractor.

ECPs in a competitive program present two complications. First, a cost-reducing change by one contractor may increase the cost of the other contractor. Second, a Class II ECP for one contractor may be classified as a Class I change for the other contractor. The two complications could diminish the ability of one of the producers to compete effectively.

These potential complications can be avoided by government control of configuration matters. The participation of both contractors on the CCB and CCB approval of Class II changes, as well as Class I proposals, would enable the program office to assess the effect of all changes on both contractors.

Another approach to controlling potential logistics problems is to insist that the two contractors have compatible configuration management systems. This can be achieved by requiring the second source to demonstrate compatibility with the developer's system as part of his response to the second source RFP. The use of compatible configuration control systems has several advantages. For example, technology transfer is enhanced. Design specifications can be transferred through compatible computer systems, thus avoiding creation of unnecessary drawings and other paper. In addition, effective government configuration audits can be accomplished efficiently. Finally, the contractors and the government can discuss design

changes with reference to the same control numbers. The use of compatible systems avoids many of the problems associated with technology translation on a competitive production program.

Configuration control can be further enhanced by the use of identical test equipment by both contractors. The program manager should specify the use of identical sets of test equipment down to the lowest level of commonality. This will enhance product quality, as well as introduce limitations on design flexibility. On the other hand, this rigid constraint may also limit potential cost reduction by the second producer. The cost advantages of relaxing the constraint should be investigated following second source production qualification.

Vigorous configuration management and adequate program office visibility can diminish the potential adverse effects of competitive production on logistic support. As discussed, special emphasis must be placed on configuration control by the program office. Therefore, the program manager must anticipate increased configuration management activity and plan for additional support and personnel. This activity may extend to key subsystem suppliers as well as the system contractors. To ensure adequate control, configuration management must address all critical items down to the lowest level of equipment commonality.

15.2   MAINTENANCE CONCEPT

The prudent program manager will require that the level
of commonality between the two producers' equipment be consistent
with the system maintenance concept. Thus, if two-level
maintenance is planned, the contractors would be required to
produce systems with interchangeable shop replaceable units
(SRUs). By determining the level of equipment commonality, the
maintenance concept also determines the degree of configuration
control that must be exerted, as well as the degree of design
flexibility afforded to the contractors. These
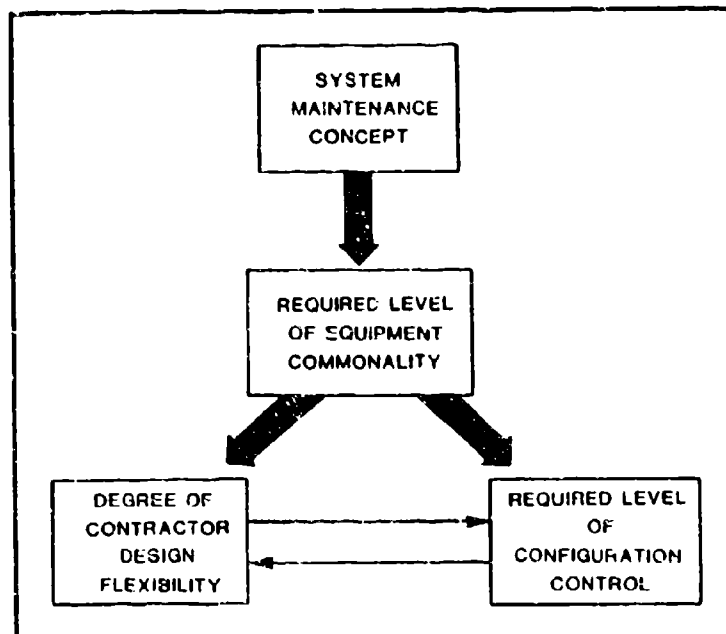interrelationships are summarized in Figure 15.2-1.

Figure 15.2-1   Maintenance Concept Relationships

Because the weapon system maintenance concept often is undefined early in a program, the program manager may have the opportunity to investigate alternative support concepts in relation to production competition. Within the general support requirements of the system, the program manager can investigate possible trade offs between design flexibility and potentially increasing support costs. For example, compatible designs at the fault isolation level would reduce potential spare parts complications; however, early in the program the fault isolation level is often undetermined. A most efficient fault isolation level, reflecting operational requirements and production competition issues, could be identified by analyses conducted by the program office and the system developer. Deviations from this goal, to enhance production competition, can be investigated and approved on the basis of economic analysis.

In particular cases, the support concept is the key determinant of logistics costs. For example, a tactical missile may be maintained in cold storage. In this case, the frequency of missile testing, rather than subsystem failure, may be the key contributor to logistics costs. Thus, design differences below the system level may have a negligible effect on cost, compared to frequency of testing.

In other cases the program manager may be faced with two-level or three-level maintenance concepts. The system may be complex, involving expensive subsystems, spare parts, and maintenance training. In such cases, commonality at the

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throwaway level may be preferred. The use of built-in test equipment (BITE), consistent with the system configuration, may enhance fault isolation and reduce maintenance downtime. In a competitive production program, interchangeability of the contractors' subsystems at the BITE level can diminish potential logistics problems.

Interim contractor support (ICS), through engineering support contracts or warranties, can also diminish potential logistics problems. The program manager must assess the potential of warranties with adequate consideration of two key factors. First, the transfer of the system to organic support must be adequately addressed. The use of warranties or ICS simplifies initial support; however, they may also conceal configuration differences that could have significant adverse effects when transitioning to organic maintenance.

Another warranty issue is the willingness of the second producer to warrant his end items produced from another contractor's design. The second producer may consider such an arrangement as too risky. Similarly, it is unlikely that the developer will warrant the second producer's end items. Thus, the program manager may face the potential for warranted and unwarranted items in the inventory simultaneously.

In concluding this chapter, it is important to note that competitive production also presents several logistics advantages. If the contractors' end items are common, the two

production sources are capable of competing for follow-on spares. In addition, if alternative suppliers have been developed, the potential for competitive break out is enhanced. Thus, potential cost savings resulting from spare parts competition may offset potential cost increases which production competition may introduce in other logistics areas.

16. OTHER CRITICAL ISSUES

The use of production competition as an acquisition strategy affects all aspects of the program. Several authors have discussed specific areas that the program manager should consider.[1] These areas include the following:

- Facilities
- Value engineering
- Spare parts procurement
- Product performance agreements
- Preplanned product improvement

This chapter discusses the relationships between these areas and the execution of a competitive production program.

16.1   FACILITIES

The establishment of two production facilities for a weapon system or component presents the program manager with issues in two areas: capacity determination and productivity planning. The program manager must determine the capacity required by the government at the two production plants. Furthermore, the program manager must investigate the use of industrial modernization incentives at one or both facilities.

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[1]"Production Competition Workshop," Defense Systems Management College, Fort Belvoir, Virginia, April 1983.

Capacity Considerations

One often-cited concern is that production competition may lead to excess capacity at the contractor plants, due to splitting the production buy.[2] This excess capacity leads to a higher overhead burden and thus to a higher unit cost.

The program manager can reduce this cost through proper facilities planning.[3] If a competitive production program is planned, the program manager should anticipate the establishment of two production lines, each one smaller than that established under a single source approach. The problem facing the program manager is to determine the most efficient size of the two facilities.

To determine an efficient size of the production line, the program manager must undertake economic and technical analyses. A simple economic approach can be adapted from economic theory and recent empirical research. Theory suggests that as production rate increases, unit cost decreases due to increased overhead absorption and production efficiencies. This declining unit cost can be mathematically represented in many

[2]M. N. Beltramo and D. W. Jordan, "A Brief Review of Theory, Analytic Methodology, Data, and Studies Related to Dual Source Competition in the Procurement of Weapon Systems," Science Applications, Inc., August 1982.

[3]Louis A. Kratz, "Dual Source Procurement: An Empirical Investigation," The Analytic Sciences Corporation, EM-223-WA, August 1983.

ways. A simple way is to represent the unit cost decline as similar to the progress curve, as shown in Figure 16.1-1.[4]
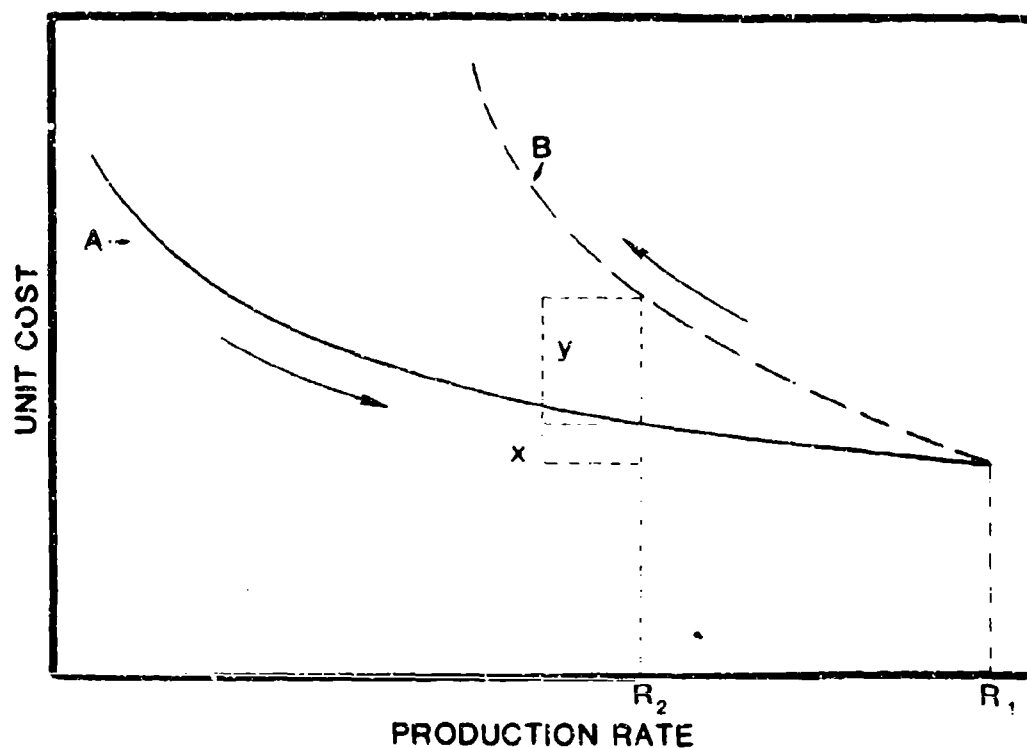
Figure 16.1-1   The Effect of Production Rate on Unit Cost

As production rate increases, unit costs decline. During the buildup phase of a production program, a contractor will incrementally increase the amount of dedicated tooling on-line. This is reflected as a movement down curve A, to some point R_1.

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[4]John E. Bemis, "A Model for Examining the Cost Implications of Production Rate," CONCEPTS, The Journal of Defense Systems Acquisition Management, Volume 4, Number 2, Spring 1981.

The production rate in effect at R_1 is determined
by a variety of factors, such as operational requirements,
special tooling and test equipment constraints, and manpower
considerations. Thus, detailed engineering and manufacturing
analyses may be required to identify R_1 for a particular
program, in a particular plant. For this discussion, R_1 can
be viewed as the planned single source capacity requirement. For
example, a production program may entail a planned buy of 3,000
units per year, based upon operational and manufacturing
considerations.

The program manager of a competitive production program
must determine the size of two facilities, given a split buy.
Tooling two lines to R_1 clearly would be inappropriate. The
program manager should recognize that once capital equipment is
on-line, production rate cutbacks may have a more dramatic effect
on unit cost than would be expected from line A.[5] The unit
cost production rate curve would be steeper than line A, as
represented by B. Thus, production rate cutbacks to R_2 due
to a split buy may have large effects on unit cost as shown by Y

In contrast, if the program manager initially had
tooled the line to R_2, the inefficiency would be represented
by X. Thus, a small inefficiency with regard to rate may be
incurred due to the split buy. However, the magnitude of the

[5]"The Affordable Acquisition Approach Study: Part
Two, Final Briefing," Air Force Systems Command, Headquarters,
Andrews Air Force Base, Maryland, February 1983.

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effect can be controlled by proper planning. The R_2 rate shown in Figure 16.1-1 can be viewed as the competitive production facilities rate. This point should be determined based upon manufacturing analyses. Often, a particular piece of capital equipment may be the determining factor. For example, special test equipment may be the pacing production equipment.

An example of facility sizing can be seen by reviewing current AMRAAM planning. AMRAAM is to be procured at a maximum rate of 3,000 per year. Thus, a single source producer would be required to produce 3,000 items per year. Furthermore, additional capacity for mobilization would be required. The prime contractors participating in the AMRAAM program are currently preparing facilities for a normal rate of 1,800 per year. The normal rate would be produced on a single shift basis, eight hours per day, five days per week. Final checkout equipment would be used for two shifts. In addition, the contractors must maintain surge capability up to 3,000 units per year, assuming two shifts.

Once the preferred facility size is identified, the program manager is faced with two related issues:

- Funding of capital costs
- Industrial modernization initiatives

Funding Capital Costs

The program manager must determine the proper
level of government investment in the contractors' production
facilities. It has been suggested that the government should
fund the necessary capital equipment in both facilities. Others
have argued that the contractors should undertake the required
capital investment. This issue is complicated during programs in
which high capital costs are anticipated.

In general, the program manager should encourage the
contractors to undertake all necessary investment in general
purpose equipment. It must be remembered that contractor
equipment and facilities are a necessary condition for producing
weapon systems. Therefore, the contractors should undertake all
investment required to do business, their profit or fees
representing the return on investment.

On the other hand, the risk associated with capital
investment in the defense industry is high.[6] Contractors
invest in equipment based upon projected annual buys; however,
these buys often are reduced due to budget constraints. Thus,
the contractor is faced with reduced returns to capital and
excess capacity. To offset this risk, the government typically

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[6]Jacques S. Gansler, The Defense Industry, MIT
Press, Cambridge, Massachusetts, 1980.

funds special tooling and test equipment. This equipment is unique to the particular weapon system and remains government-owned property. In a competitive production program, it may be necessary to fund two sets of special tooling and test equipment.

The shared investment approach may be insufficient if high amounts of contractor investment are required. In such cases, the program manager should consider indemnifying the contractor's investment for a given quantity over a specified period. This approach was employed successfully on the GAU-8 30-millimeter ammunition program. The program manager should note that this approach involves use of an unfunded contingent liability which may require review and approval by higher authority.

Industrial Modernization Initiatives

Recent concern over the productivity of the defense industrial base has led the DoD to implement the Industrial Modernization Incentives Program (IMIP). The objective of IMIP is to develop, test, and refine contract incentives encouraging industry to make productivity enhancing capital investments. The incentives include shared savings rewards, and contractor investment protection.[7]

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[7]A. Douglas Reeves, "The Industrial Modernization Incentives Program: An Experimental Effort to Improve Defense Contractor Productivity," Industrial Productivity Directorate, Office of the Under Secretary of Defense (Research and Engineering), December 1983.

On a single source production program, IMIP projects can be evaluated using standard return-on-investment criteria. On a competitive production program, IMIP presents several complex issues, including the following:

- Should incentives be applied to both contractors?

- Given the differences in production processes, how can incentives be applied fairly?

- How are shared savings to be calculated in a competitive environment?

- What is the effect of shared savings on contractor pricing in a competitive environment?

The program manager must investigate these issues in detail when considering the use of IMIP on a competitive production program. Sharing arrangements, indemnification, and potential pricing strategies must be reviewed to ensure that one contractor does not attain an unfair advantage over the other through government initiatives. The program manager should recall that one of the benefits attributed to production competition is increased capital investment. Contractors may invest in capital equipment in a competitive environment to enhance their competitive advantage. The program manager should consider this potential benefit when assessing IMIP applications.

16.2   VALUE ENGINEERING

Value engineering presents another circumstance where shared savings may complicate a competitive production program. FAR 48.1 describes the value engineering process. Value engineering was developed to provide contractors with an

incentive to lower costs. It has been argued that contractors do not introduce cost-reducing change proposals, because lower costs would eventually lead to lower profits, since profits are calculated primarily based on cost. Value engineering is used to correct this problem by sharing the cost reductions with the contractor. Thus, the firm receives a return on its cost-reducing change proposals.

In a competitive environment the applicability of value engineering is questionable, because competition provides an incentive for contractors to develop cost-reducing changes. On the other hand, under a value engineering clause, a contractor may propose a cost-reducing change that is classified as a Class I ECP, thereby requiring a configuration change. Both contractors would incorporate the change if approved. The contractor that submitted the value engineering change would share in the savings for the total number of items produced by both contractors during the sharing period, as specified in the value engineering clause. Thus, the contractors are provided with an incentive to propose value engineering changes.

Another method of encouraging value engineering change proposals is to provide the developing contractor with "credits" in future source selection processes. The "credits" would be used to enhance the contractor's position in determining the quantity split. This approach has the advantage of not requiring direct payments to the developing contractor. This innovative approach was used successfully on the TOMAHAWK program.

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16.3   SPARE PARTS PROCUREMENT

Competitive production of end items presents the program manager with several opportunities for competitive spare parts procurement. The program manager must also recognize that production competition may involve short term complications.

In general, initial spares are procured under Basic Ordering Agreements (BOAs), due to difficulties in identifying initial spares requirements. The BOA provides a way of obtaining spares in a timely manner; however, it may be uneconomical in that the advantages of quantity ordering are not attained. Due to potential differences in design and manufacturing in a competitive production program, initial spares should be procured from both contractors, each contractor providing spares for its fielded system.

As the system matures, the program manager should consider competitive procurement of common spares. The contractors could submit cost proposals as part of their production proposals, or a separate competition could be held.

The program manager also may consider competitive break out of selected spare parts. If the prime contractors developed alternative suppliers as part of their production program, this approach could result in considerable savings. By competitively breaking out selected spares, the program manager could reduce

overhead layering and attain competitive prices. The program
manager must recognize that this approach may require additional
program office personnel.

16.4   PRODUCT PERFORMANCE AGREEMENTS

Product performance agreement is a generic term used to
refer to warranties and guarantees. DoD recently has placed
increased emphasis on the effective use of warranties and
guarantees to ensure that end items fulfill their operational
requirements. Under a product performance agreement, a
contractor agrees to repair or replace, at a fixed cost, any item
that fails to meet a specified performance requirement.

A specified performance requirement is any specifically
delineated mandatory performance requirement set forth in a
government production contract for a weapon system or in any
other agreement relating to the production of such system. Often
used requirements include reliability, availability, and spares
stock levels. The fixed price of the product performance
agreement provides both positive and negative financial
incentives to contractors to emphasize life-cycle considerations
during equipment design and initial production.

The development and application of product performance
agreements is a complex undertaking that requires detailed

analysis.[8] The complexity of the issue has led to the

establishment of a Product Performance Agreement Center (PPAC),

located at Wright-Patterson Air Force Base, Ohio, under the joint

sponsorship of Air Force Systems Command and Air Force Logistics

Command. For detailed information concerning warranties and

guarantees, the program manager is referred to PPAC.

The program manager should recognize that warranties

are required on major items. Section 794 of the FY84 Department

of Defense Appropriations Act requires the inclusion of

guarantees in all new procurements, unless the Secretary of

Defense determines that a guarantee would not be cost effective

The implementation of this requirement is currently an area of

debate; however, the program manager should anticipate that the

use of warranties will be examined in the program review process.

As discussed in Chapter Fourteen, the use of warranties

may be difficult in a competitive production program. The second

source contractor may be unwilling to warrant end items that were

produced from another manufacturer's design. Thus, the program

manager may be faced with fielding warranted and nonwarranted

items.

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[8]"Product Performance Agreements: Historical
Perspectives," The Analytic Sciences Corporation, SP-4630-1, May
1983.

On the other hand, the existence of two producers provides the program manager with an opportunity to procure warranties in a competitive environment. In a competitive production program, the price of the warranty or guarantee could be incorporated as a source selection criterion in determining the quantity split. A recent example of this approach is the Air Force Alternate Fighter Engine (AFE) program.

The AFE program involved a form, fit, and function competition between the General Electric F101-GE-100 engine and the Pratt and Whitney F100-PW-220 engine. The initial award in FY84 resulted in General Electric receiving 75 percent of the annual buy and Pratt and Whitney receiving the remaining 25 percent. The Air Force estimates that their acquisition strategy resulted in a life-cycle cost savings of between $2.5 and $3 billion. The Air Force also contends that contractor responsiveness was improved.

In addition, the Air Force feels that the AFE program competition, paramount to negotiating a good warranty at a reasonable price, allowed the Air Force to obtain, at a reasonable price, the most comprehensive warranty ever provided for a DoD aircraft engine. The AFE warranty requires the contractor to correct deficiencies in material and workmanship, replace unuseable or unserviceable engines or components, guarantee total engine removal rates, and assure that engines retain their performance within a defined time limit or a

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specified number of tactical cycles. Further, the government
itself can repair or replace a failed item under warranty, and
the contractor will reimburse the government within specified
conditions.

16.5   PREPLANNED PRODUCT IMPROVEMENT

Preplanned product improvement (P^3I) presents
another area in which the program manager could take advantage of
competitive production. P^3I is a recent initiative
developed to field systems quickly with a limited capability and
to improve these systems in a planned, systematic manner. Often
the improvements incorporate field responses to the equipment.

In a competitive production program, the program
manager has direct access to two qualified sources who could
develop the product improvement. The two sources could provide
competing design teams, thus enhancing technical achievement.
Furthermore, the two contractors would be more cost conscious,
knowing that a competitor was developing a similar improvement.

These advantages are offset to a degree by additional
development costs and potential logistics complications. The use
of P^3I in a competitive environment may lead to a
multiplicity of designs in the inventory. The program manager
must anticipate this potential problem and exercise the level of
configuration control necessary to avoid large cost increases.

16.6   SUMMARY OF OTHER ISSUES

This chapter has presented several issues related to production competition. In general, these are areas in which the program manager can use competition to the advantage of the government. The program manager is cautioned that these advantages are not automatically obtained. Rather, they require careful planning and execution. Specifically, the program manager should undertake the following:

- Conduct detailed economic and engineering analyses to identify preferred facility size.

- Allow the force of competition to stimulate contractor investment in general purpose equipment.

- Rely on competition as an incentive for cost-reducing design changes, but pro ide contractors with additional incentives for cost-reducing Class I change proposals.

- Extend the competitive environment into the procurement of spare parts.

- Take advantage of the force of competition in the areas of warranties and P^3I.

APPENDICES

APPENDIX A

PRODUCTION COMPETITION

A PRODUCTION COMPETITION

In developing a production competition program, the program manager is presented with several methods in which competition can be applied to a particular program. Numerous characteristics define the methods of competition and thus influence the important production, economic, and incentive structures that the program manager must assess. Two dimensions can be used to define the different methods of competition: the number of production sources and the number of competitions undertaken. These two dimensions give rise to four methods of competition:

- Winner-take-all, single competition
- Winner-take-all, reprocurement
- Split award, single competition
- Split award, reprocurement

These methods present different characteristics and different incentives to the competing contractors.

A.1 WINNER-TAKE-ALL, SINGLE COMPETITION

This method of applying competition involves a competition at the beginning of the production cycle in which the winner receives the entire production quantity. The single competition provides a large incentive to buy in, since no pressure or threat of competition is brought to bear throughout the production cycle. Further, if the producer experiences cost

increases, performance failures, or schedule problems, the program manager must either accept the results or begin the long and costly process of qualifying a second producer. The benefits of competition cannot be assumed to remain after the production contract is awarded and the previously qualified second source is removed from contention.

The program manager can distinguish this method from other production competition methods by noting that the single competition is really competition for production. Continuous competition can be viewed as competition during production.

The winner-take-all method was demonstrated recently by the Air Launched Cruise Missile. The program involved competitive development efforts during full-scale development (FSD) leading to a competitive fly off. A single contractor was selected to proceed into production.

A.2   WINNER-TAKE-ALL, REPROCUREMENT

This method of competition is used primarily to procure spare parts, rather than production end items. The method suffers from severe limitations in relation to complex systems; however, it may prove useful for less complex end items such as ammunition and electronic subsystems.

The winner-take-all, reprocurement method involves a series of winner-take-all competitions held throughout the

production cycle. A firm has less incentive to buy in, because
if it allows costs to rise, it may become noncompetitive at the
next production point and face the loss of all of its production.
The program manager must recognize that once a firm obtains the
contract, no other firm is producing. Therefore, no other line
is "warm" and no direct competitors exist. Further, the
potential competitors at the next bidding point may find it hard
to incorporate required configuration changes and manufacturing
technology which would make them competitive.

If employed for complex end items, this method also
presents the program manager with configuration control
complexities. If the prime contractor producing the item changes
due to competitive awards, contractor responsibility for
configuration control will become confused. The system developer
who is not in production may have no interest in maintaining the
configuration. If the system developer does retain design
responsibility, the second source will be hesitant to suggest
changes.

These limitations have precluded the use of this method
on prior competitive production programs. The method does
present a viable approach to procuring simple subsystems
competively. Thus, the program manager should consider this
method when assessing potential subsystem break out.

A.3   SPLIT AWARD, SINGLE COMPETITION

In this case, there is one competition at the beginning
of the production cycle leading to a split buy between two
competitors according to some predefined formula. The quantity
may be split 80/20, or in some other ratio, or the bids may
determine the final split. Even though no further formal
competitions are held, each firm is aware that if its costs rise,
or if its schedule or performance slip unacceptably, the program
manager may increase the competitor's share. The force of
competition is maintained, but not through formal price
competitions.

This method may present the program manager with a
viable approach toward establishing two production sources, if
the primary goal of the program is industrial base development.
The single split enables the contractors to plan production
facilities efficiently and to order components and subsystems in
economically efficient quantities. Used in conjunction with
multiyear procurement, this method can establish two efficient
production sources of an end item while decreasing the
administrative burden on the program office.

A.4   SPLIT AWARD, REPROCUREMENT

In this case, the production quantity is split between
two producers, but the split may be changed through a series of
reprocurements. The firms do not face the threat of losing their

A-4

production quantity entirely; however, they may have it reduced substantially if they are not competitive at the next bidding point. Since the firm is certain of obtaining some quantity of production, it faces less competition than in a winner-take-all reprocurement. However, it also has an up-and-running competitor ready to take over its production if it experiences problems.

A problem with these competitions is that they present a contractor with the opportunity to submit artificially high bids for the small production quantity portions of the buy, thereby obtaining excessive profit levels. The program manager can counter this problem by developing a source selection plan that presents the competitors with the potential for a zero award. Furthermore, detailed audits and negotiation could be used to ensure reasonable pricing of the lower quantity share.

This method of production competition has been employed successfully on several prior DoD programs, including AIM-7F, AIM-9/G, the GAU-8 30-millimeter ammunition, and HELLFIRE.

APPENDIX B

PRIOR EMPIRICAL STUDIES
OF PRODUCTION COMPETITION

B   PRIOR EMPIRICAL STUDIES OF PRODUCTION COMPETITION

Numerous studies of production competition have been undertaken. In general, these efforts have employed different data sets and different methodologies resulting in a diversity of results. Furthermore, many of these studies present results in an aggregate form, using measures such as average savings achieved.

Fortunately, research on production competition has increased in sophistication as researchers have obtained a clearer understanding of the complexities of production competition. Several research efforts have concentrated on the effect of competition on contractor price behavior. These efforts have supported the development of the economic analysis that is presented in Chapter Four. The purpose of this appendix is to trace the historical evolution of the economic analysis by reviewing the following works:

- U.S. Army Electronics Command (February 1972)
- Zusman and Asher (March 1974)
- Lovett and Norton (October 1978)
- Daly, Gates, and Schuttinga (September 1979)
- Drinnon and Hiller (December 1979)
- Kratz and Cox (May 1982)

In addition, several recent studies have addressed other critical issues associated with production competition. One such study is

by Greer and Liao (October 1983). This effort presents an analysis of the relationship between production capacity and program savings. This effort is also summarized.

B.1   U. S. ARMY ELECTRONICS COMMAND

"The Cost Effects of Sole Source vs. Competitive Procurement," U.S. Army Electronics Command, Cost Analysis Division, Comptroller, February 1972.

In 1972 the U.S. Army Electronics Command (ECOM) published a study of weapon system components which previously had been procured sole source, but which eventually were procured competitively. The study analyzed 13 cases and found that unit price reductions averaged 54 percent upon the introduction of competition. Furthermore, a prediction confidence of 40 percent price reduction was identified for planning purposes.

The methodology used by ECOM was to calculate, for each component, the difference between the last sole source price and the first competitive price, thus obtaining a unit price reduction figure. That number then was multiplied by the total number of units in the competitive buy in order to obtain total "savings" due to competition. Savings, as a percentage, were calculated simply as the difference between the two prices divided by the old sole source price.

The ECOM--72 da a base was comprised of radio sets, test sets, and other electronic components. The price data (from FY62--FY70) were not adjusted for inflation. The analysis

considered neither the nonrecurring costs of establishing the competitive sources, nor the learning curve effects.

B.2   ZUSMAN AND ASHER

M. Zusman and N. Asher, et.al., "A Quantitative Examination of Cost Quantity Relationships, Competition During Reprocurement, and Military Versus Commercial Prices for Three Types of Vehicles," Institute for Defense Analyses, Program Analysis Division, Study No. S-429, March 1974.

In early 1974, Zusman and Asher at the Institute for Defense Analyses (IDA) published a large study which included an evaluation of competition during reprocurement of weapon systems and components. The study found that, for the 20 cases analyzed, unit price reductions averaged 37 percent upon the creation of a competitive production source. The data base consisted of several small missiles, a bomb, and various electronic items.

The study methodology differed substantially from 's, in that it extrapolated the last sole source price down previously established learning curve to determine what the sole source price would have been in the absence of competition. This extrapolated sole source price was then compared to the competitive price in order to calculate the percentage savings and the total dollar savings attributable to the introduction of competition during production.

The analysis, using data from FY57 to FY73, was adjusted for inflation. Like ECOM--72, it did not consider the nonrecurring costs of establishing the competitive sources.

Thus, the savings presented in Table B.2-1 must be considered as gross savings.

TABLE B.2-1
ZUSMAN AND ASHER
PERCENTAGE SAVINGS DUE TO COMPETITION

PROGRAM	GROSS PERCENT SAVINGS
TOW Missile	48.1
SHILLELAGH	- 0.2
TALOS (G&C unit)	42.3
BULLPUP 12 (Martin)	13.9
BULLPUP 12 (Maxson)	45.8
HAWK Motor Parts	6.4
MK-48 Torpedo Warhead	53.2
MK-48 Electric Assembly	37.5
TD-204 Cable Combiner	50.2
TD-202 Radio Combiner	52.5
TD-352 Multiplexer	57.8
TD-660 Multiplexer	30.2
60-6402 Electric Control	57.0
APX72 Airborne Transponder	32.6
SPA-25 Radar Indicator	21.3
USM-181 Test Set	36.0
FGL-20 Teletype	32.0
MD-522 Modulator	60.3
CV-1548 Signal Converter	53.7

B.3   LOVETT AND NORTON

E. T. Lovett and M. G. Norton, "Determining and
Forecasting Savings from Competing Previously Sole
Source/Noncompetitive Contracts," Army Procurement
Research Office, APRO 709-3, October 19"

Based on the two prior efforts, Lovett a ' orton

reviewed the price behavior of contractors on 11 competitive

awards that had previously been sole source. The data set

included three tactical missiles and assorted electronic systems.

Recurring savings were calculated by extrapolating the sole

source learning curve to identify the would-have-been sole source

price and then comparing this price to the achieved competitive

price in constant dollars. It is important to note that Lovett

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and Norton compared only those two prices. There was no
consideration of follow-on competitive prices. Their approach is
shown graphically in Figure B.3-1.
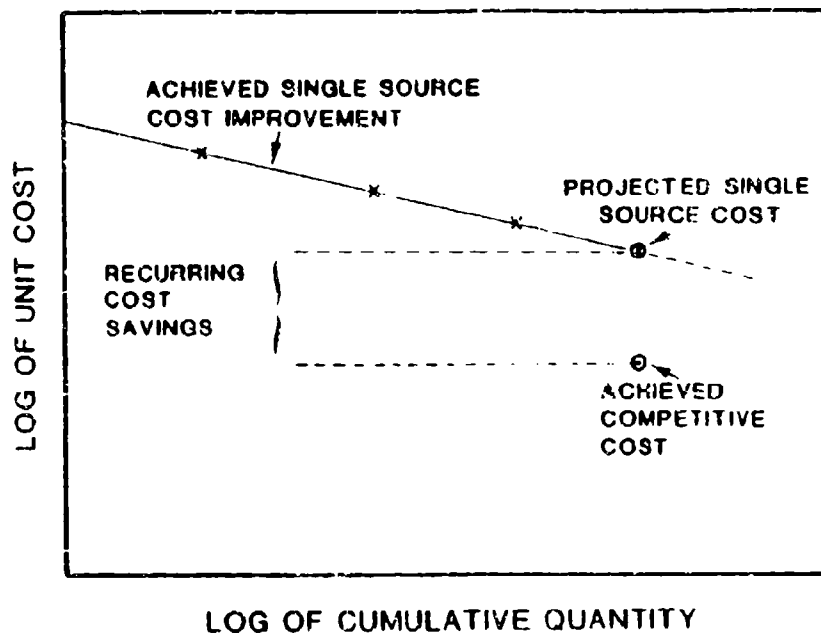
Figure B.3-1   Lovett and Norton Methodology

Based upon the two prices shown in Figure B.3-1, Lovett
and Norton estimated percent savings due to competition. This
was achieved by calculating dollar savings as price savings times
the quantity procured. The dollar savings were then divided by
the total program recurring costs.

The savings identified by Lovett and Norton using this
method considered only recurring cost. The methodology did not
address the nonrecurring costs associated with establishing the
second source. The savings identified by Lovett and Norton are
presented in Table B.3-1.

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TABLE B.3-1
LOVETT AND NORTON
PERCENTAGE SAVINGS DUE TO COMPETITION

PROGRAM	GROSS PERCENT SAVINGS
TOW Missile	8.5
TOW Launcher	30.2
DRAGON Round	2.7
DRAGON Tracker	12.0
SHILLELAGH	5.9
FAAR Radar	16.6
FAAR TADDS	18.2
AN/ARC-131	-2.1
UPM-98 Test Set	3.0
PP-4763/GRC Power Supply	.3
AN/PRC-77	34.8

B.4   DALY, GATES, AND SCHUTTINGA

G. G. Daly, H. P. Gates, and J. A. Schuttinga, "The Effect of Price Competition on Weapon System Acquisition Costs," Institute for Defense Analyses, Program Analysis Division, Paper No. P-1435, September 1979.

In 1979, Daly, Gates, and Schuttinga expanded upon the work that had been performed at the Institute for Defense Analyses (IDA) in 1974 by Zusman and Asher. Daly, Gates, and Schuttinga examined 31 competitive reprocurements.

The methodology for examining the 31 programs was in accordance with earlier IDA procedures: the last sole source price was extrapolated down its learning curve to obtain a figure which would be compared with the competitive price. The IDA--79 data were adjusted for inflation; however, production rate effects were not evaluated, and technology transfer costs were not considered. The IDA model for describing the effects of competition attributes all savings to a steepened

post-competition learning curve. A rationale for the steepened curve is not presented.

The data base consisted of five missiles, a bomb, a guidance and control unit, and an assortment of electronic components. The analysis showed an average unit price reduction equal to 35 percent. The authors suggest that program planners should assume the following price reductions when competition is introduced into previously sole source production programs:

- 10% reduction for split-award.
- 20% reduction for winner-take-all buy outs.

The gross savings identified by Daly, Gates, and Schuttinga are shown in Table B.4-1.

TABLE B.4-1
DALY, GATES, AND SCHUTTINGA
PERCENTAGE SAVINGS DUE TO COMPETITION

Program	Gross Percent Savings
TOW Missile	8.9
SHILLELAGH	-8.0
TALOS (G&C unit)	40.8
BULLPUP 12 (Martin)	31.7
SIDEWINDER AIM-9D/G	-4.6
SIDEWINDER AIM-9B	1.6
Standard Missile MR RIM 66A	-4.2
HAWK Motor Parts	45.7
TOW Launcher	44.2
Rockeye Bomb	-23.0
TD-204 Cable Combiner	62.1
TD-202 Radio Combiner	46.8
TD-352 Multiplexer	58.0
TD-660 Multiplexer	38.3
60-640 Electric Control	49.4
APX72 Airborne Transponder	27.1
AN/ARC-54	55.0
AN/PRC-77	20.5
AN/GRC-106	43.3
AN/GRC-103	58.7
AN/APM-123	61.2
SPA-25 Radar Indicator	48.8
USM-181 Test Set	56.0
FGL-20 Teletype	23.7
MD-522 Modulator/Demodulator	58.6
CV-1548 Signal Converter	64.0
MK-980/PPS-5	56.0
PRT-4	42.3
Aerno 42-0750	54.8
Aerno 42-2028	19.9

B.5   DRINNON AND HILLER

> J. W. Drinnon and J. R. Hiller, "Predicting the Costs
> and Benefits of Competitive Production Sources," TASC
> Report 1511, December 1979.

Drinnon and Hiller expanded upon the efforts of Lovett
and Norton in 1979. In their review of 45 programs, Drinnon and
Hiller employed an approach similar to that used by Lovett and
Norton. The approaches differed in that Drinnon and Hiller
calculated savings based only upon the remaining production

quantity. The authors argued that costs incurred prior to competition should not enter into the percent savings calculation.

The savings identified by Drinnon and Hiller are presented in Table B.5-1. The savings do not include consideration of nonrecurring costs. Thus, they must be considered as gross savings, rather than net savings.

TABLE B.5-1
DRINNON AND HILLER
ESTIMATED PERCENTAGE SAVINGS DUE TO COMPETITION

Program	Gross PercentSavings
AN/APM-123	67.7
MK-980/PPS-5	66.5
AN/ARC-54	63.1
MK-48 Torpedo Test Set	61.8
MK-48 Torpedo Exploder	61.2
AN/GRC-103	60.1
Standard Missile, MR RIM 66A	59.2
AN/ARA-63 Radio Receiver	57.9
TD-352 Multiplexer	55.6
60-6402 Electric Control	52.7
MD-522 Modulator/Demodulator	51.9
HAWK Motor Metal Parts	49.9
MK-48 Torpedo Warhead	48.6
MK-48 Torpedo Electric Assembly	47.0
CV-1548 Signal Converter	45.4
AN/FYC 8X	43.2
TD/204 Cable Combiner	42.0
AN/PRC-77 Radio	41.9
AN/GRC-106	41.8
TD-202 Radio Combiner	40.2
FGC-20 Teletype Set	39.9
TALOS Missile	39.8
USM-181 Telephone Test Set	36.3
Standard Missile, ER RIM 67A	34.0
AN/SGS 23 208A Transducer	32.3
TOW Launcher	30.2
TD-660 Multiplexer	28.4
BULLPUP 12B Missile	26.5
APX72 Airborne Transponder	23.3
FAAR TADDS	18.2
FAAR Radar	16.6
TOW Missile	12.3
DRAGON Tracker	12.3
UPM-98 Test Set	11.5
AN/ASN-43	10.7
SPA-25 Radar Indicator	10.7
SHILLELAGH	9.4
DRAGON Round	7.8
SIDEWINDER AIM-9D/G	0.7
PP-4763/GRC Power Assembly	0.5
SPA-66 Radar Indicator	-3.4
Rockeye Bomb	-4.5
SIDEWINDER AIM-9B	-5.6
AN/ARC-131 Radio	-16.1

Of more significance was Drinnon and Hiller's review of Ford Aerospace price behavior in the SHILLELAGH program. This

review concentrated on the effects of continuing competitions. Sufficient data points enabled the identification of pre- and post-competition learning curves. Their review led to the development of a theoretical framework for assessing continuing production competition. They postulated that establishment of production competition led to the following:

- An immediate price reduction, characterized as a downward shift of the learning curve.

- Continuing improved price reductions, characterized as a rotation of the learning curve.

These effects are shown in Figure B.5-1.
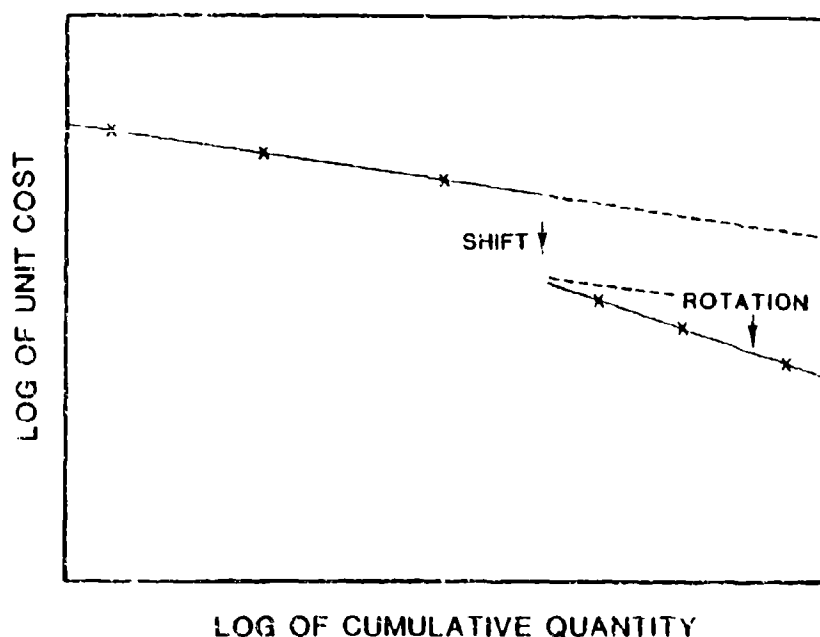

LOG OF CUMULATIVE QUANTITY

Figure B.5-1   Drinnon and Hiller Framework

It is important to note the framework was developed based on one case, applied only to the original producer, and did

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not result in a statistically significant econometric model. The
authors offered the concept as an exploratory framework.

B.6   KRATZ AND COX

        Lou Kratz and Larry Cox, "Analysis of AMRAAM
        Acquisition Alternatives: Phase II," TASC Technical
        Report--4049, May 1982.

        Kratz and Cox expanded upon the conceptual framework
presented by Drinnon and Hiller in several ways:

- Investigation of second source price behavior

- Additional empirical investigations of the shift
  and rotation concept

- Incorporation of the effect of production rate on
  unit cost

The authors then applied the expanded framework to a specific
analysis of the potential effect of production competition on the
AMRAAM program.

        Kratz and Cox suggested that an established producer
would not reduce his unit price unless the second source was a
viable competitor, and applied some competitive price pressure.
The authors argued that such behavior on the part of the second
source would be evidenced by a steeper cost improvement rate or a
lower first unit cost than the initial producer's. This
hypothesis was investigated by Kratz and Cox using unit cost
improvement curves based upon fi   tactical missile programs.
The results of their analysis are summarized in Table B.6-1.

TABLE B.6-1
KRATZ AND COX
COMPARING FIRST AND SECOND SOURCE COST
IMPROVEMENT CURVES AND FIRST UNIT COSTS

| Program | Cost Improvement Rate | | Difference % | % First Unit Cost Reduction |
	First Source	Second Source		
BULLPUP	0.82	0.80	2	46
TOW	0.98	0.89	9	20
SIDEWINDER AIM-9B	0.90	0.83	8	17
SIDEWINDER AIM-9L	0.91	0.87	4	18
SPARROW AIM-7F	0.85	0.84	1	14

Given this competitive pressure, Kratz and Cox

investigated the price reaction of the initial producer on five

tactical missile programs. Their results are shown in Table

B.6-2.

TABLE B.6-2
KRATZ AND COX
INITIAL PRODUCER'S REACTIONS TO COMPETITION

Program	Contractor	Shift (%)	Rotation (%)
SPARROW	Raytheon	4	8
BULLPUP	Martin	14	13
TOW	Hughes	15	32
SIDEWINDER AIM-9B	General Electric	9	6
SIDEWINDER AIM-9L	Raytheon	10	7

The authors noted a large variation in the shift and

rotation parameters estimated from prior programs. In an attempt

to explain the variations, the authors developed the concept of a best competitive curve.

The curve represents the continuing cost improvement curve which begins with the historically derived, noncompetitive first unit cost a achieves parity with the competitive last unit cost. It represents what might have happened had the original producer been under continuing competitive pressure from the outset. The Kratz and Cox concept is shown in Figure B.6-1.
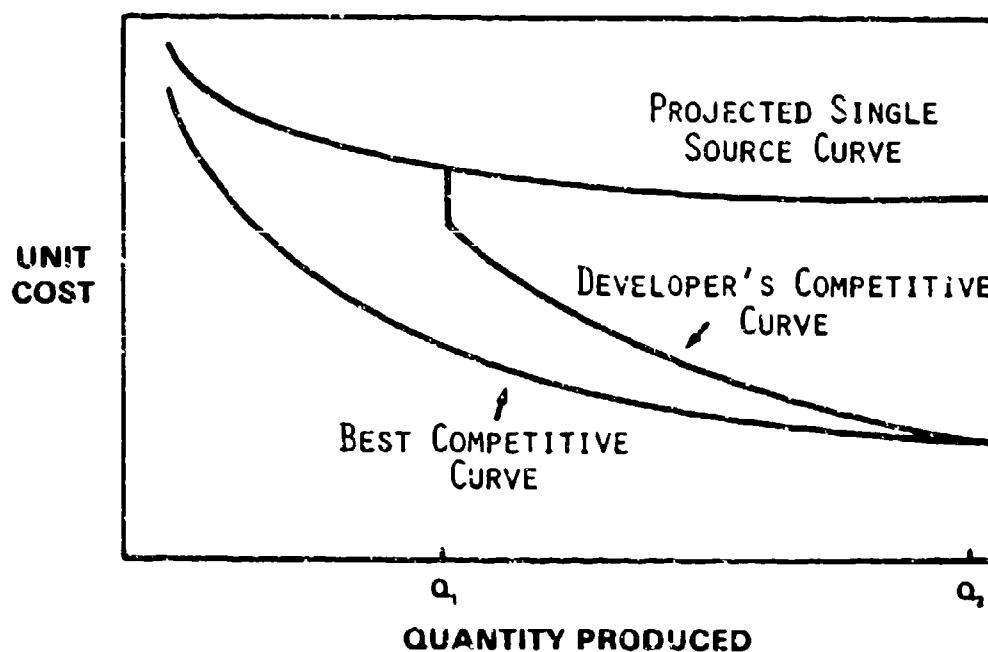

Figure B.6-1   Hypothetical "Best Compe itive" Curve

Kratz and Cox compared the slope of the hypothetical best competitive curve to the achieved single source curve for the five tactical missile programs using simple linear regression. This resulted in equation B.6-1.

Comp. Rate = .184 + .757 (single source rate)   (B.6-1)

Where:

Comp. Rate = best competitive cost
improvement curve

Single source rate = the achieved single source
cost improvement curve
prior to competition

Given this result, the authors suggest the "best competitive" curve provides a means to explain the observed cost behavior of the original producers. The observed shifts and rotations (of varying magnitudes) of the original producer's cost improvement curve can be characterized as making up for earlier cost improvements which were possible, but were unrealized due to the absence of competitive pressure. This implies that the earlier competitive pressure is applied during the production phase, the earlier the original producer moves toward the best competitive curve.

Furthermore, the authors noted that the slopes of the hypothetical best competitive curves corresponded with the slopes of the competitive second source curves. In other words, the second producer, who would be attempting to be competitive from the outset, follows a (historically derived) cost improvement curve very similar to the best competitive cost improvement curve calculated for the original producer.

Kratz and Cox combined these factors into a predictive framework, in which the system developer is assumed to alter his cost behavior just enough to stay ahead of the second producer in

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a competitive environment. Thus, the authors project a system developer's shift and rotation, assuming he bids to win. The authors note that relaxing this assumption through sensitivity analyses provides a useful bound on potential savings.

Kratz and Cox lso introduced consideration of the effect of production rate variation on unit cost. They present this consideration as an exponential, similar to the cost improvement curve. The authors' formulation is shown in equation B.6-2.

$$Z = AX^B Y^C \tag{B.6-2}$$

where:

Z = unit cost of the Xth item produced

A = constant (sometimes referred to as T_1 or "first unit cost")

B = exponent which describes the slope of the quantity/cost curve

Y = (proxy) production rate in effect

C = exponent which describes the slope of the rate/cost curve

Kratz and Cox present a symmetric U-shaped production rate cost curve. This is achieved as shown in equation B.6-3.

$$Y = \begin{cases} R \text{ if } R \leq R_0 & \text{(B.6-3)} \\ 2R_0 - R \text{ if } R_0 \leq R < 2R_0 - 1 \end{cases}$$

where R is the production rate in effect for a given lot, R_0 is the optimal production rate and Y is as in equation B.6-2.

$$C = \frac{\ln q}{\ln 2}$$

q = production curve rate parameter whose interpretation is similar to that of the cost improvement curve parameter. For example, if q = .90, then a doubling of the production rate (up to R_0) results in a lowering of unit cost by 10 percent.

This production rate formulation was presented initially in:

M. Bohn, et al, "Analysis of Acquisition Alternatives for GPS User Equipment," Technical Report 1426-4, The Analytic Sciences Corporation, May 1981.

Most recently, Bohn and Kratz have presented a detailed

description of the formulation. This latter effort is summarized

in Appendix C.

B.7   GREER AND LIAO

Willis R. Greer and Shu S. Liao, "Cost Analysis for Dual Source Weapons Procurement," Naval Postgraduate School, October 1983.

Greer and Liao present a comprehensive review of recent

studies and models of production competition. Based upon this

review, the authors conclude that several key variables such as

contractor profitability and capacity utilization have received

inadequate empirical attention. To address this limitation, the

authors undertake empirical investigations in the two areas.

To address the profitability issue, Greer and Liao undertake an analysis of profit on DoD contracts covering the period 1963 through 1982. Two measures of profitability were investigated: profit as a percentage of sales and profit as a percentage of net worth. The specific investigation involved an assessment of the relationship of contractor profitability to capacity utilization.

Based on this investigation Greer and Liao conclude that program managers have been able to take advantage of the bargaining power to buy goods at substantially lower profit margins when capacity utilization is low. The returns earned by contractors on DoD business are measurably lower than the returns on commercial business during periods of low capacity utilization. In addition, the authors note that the volatility of returns is higher for DoD business, implying the risks are viewed as being somewhat higher.

Greer and Liao then investigate the relationship between savings achieved on prior competitive production programs and capacity utilization. In undertaking this investigation, the authors employ savings on prior programs as identified by Science Applications, Incorporated, and sector capacity utilization rates. These data are presented in Table B.7-1.

Procurement Program	Percent Savings or (Loss) Due to Competition	Annual Average Capacity Utilization During Dual Source Phase
TOW	26.0	63.5
ROCKEYE Bomb	25.5	70.9
BULLPUP AGM-12B	18.7	76.2
SHILLELAGH Missile	(4.7)	87.0
SPARROW AIM-7F	(25.0)	81.6
MK-46 Torpedo	(30.9)	91.6
SIDEWINDER AIM-9D/G	(71.3)	82.3

Greer and Liao use the data presented in Table B.7-1 to perform a statistical investigation. Based on the results of this investigation, they conclude that competition produces greater savings when firms are at low capacity; when industry is very active, dual sourcing is of little benefit as a cost reducer. This can be readily seen by noting that the data shown in Table B.7-1 indicates a net loss arising from competition when capacity utilization is above 80.

Greer and Liao use their detailed statistical review to offer a model of the effect of capacity utilization on unit costs. They suggest this model presents an improvement over the historic production rate models. Their formulation is shown in equation B.7-1.

$$P = k\ Q^a\ U^c\ e^{dM}\ e^{fN} \qquad\qquad (B.7\text{-}1)$$

where:

   P = average price for the buy

   Q = midpoint quantity associated with a
   particular lot

   U = smoothed utilization percentage for
   the industry

   M = dummy variable equal to 1 if the
   buy was under dual source, zero
   otherwise

   N = dummy variable equal to 1 if the buy
   was winner-take-all. zero otherwise

   e = base of the natural logarithms

k, a, c, d, f = parameters to be estimated

The parameters estimated by Greer and Liao for equation B.7-1 are presented in Appendix C. Of interest here is that Greer and Liao did identify a downward price shift due to competition, as evidenced by a statistically significant negative coefficient for M and N.

APPENDIX C

PROLUCTION RATE CONSIDERATIONS

C   PRODUCTION RATE CONSIDERATIONS

The effect of production rate variations on unit cost is a key variable in the assessment of production competition due to the nature of the competitive split buy. Numerous studies of production rate have been undertaken. This appendix summarizes the results of recent studies that present alternative formulations of the effect of production rate on unit cost. The summarized efforts include works by the following:

- Large
- L. L. Smith
- Bemis
- Bohn and Kratz
- C. H. Smith
- Greer and Liao
- Womer

C.1   LARGE

Joseph P. Large, et al., "Production Rate and Production Cost," Rand Corporation, R-1609-PA&E, December 1974.

In 1974, Rand undertook a detailed statistical study of the relationship between unit cost and production rate. This effort employed linear regression techniques to investigate the effect of production rate on manufacturing labor, materials, tooling, engineering, and labor rate. The study was based upon airframes, missiles, and aircraft engines. Based on this

investigation, the authors concluded that the influence of production rate could not be predicted with confidence. The statistical analysis presented diverse results, requiring analysis of specific programs. The study identified overhead costs as a significant determinant of the effect of production rate on unit costs.

C.2   L. L. SMITH

Larry Lacross Smith, "An Investigation of Changes in Direct Labor Requirements Resulting from Changes in Airframe Production Rate," PhD Dissertation, University of Oregon, 1976.

In 1976, Smith attempted to incorporate production rate considerations into the learning curve concept. Smith's formulation expressed labor hours as a function of cumulative quantity and production rate per period. The production rate effect was expressed similarly to the learning curve. Smith reported a significant improvement in estimating prior learning curves as demonstrated by a reduction in mean squared error.

This seminal effort by Smith has sponsored several investigations of the exponential form of the production rate parameter including work by Bemis and Kratz.

C.3   BEMIS

J. C. Bemis, "A Model for Examining the Cost Implications of Production Rate," CONCEPTS, The Journal of Defense Systems Acquisition Management, Volume 4, Number 2, Spring 1981.

Bemis expanded Smith's formulation to include total recurring unit cost. Bemis expressed total recurring unit cost

as a function of cumulative quantity and production rate per period. The model parameters were estimated by estimating lot midpoints, taking logarithmic transformations, and performing multivariate linear regression.

The Bemis formulation presents several analytic advantages. First, unlike the quadratic formulation of economic theory, the formulation can be estimated with relative ease. Second, the data necessary to estimate the model is readily available to researchers and program managers.

The Bemis formulation can be expressed mathematically as shown in equation C.3-1.

$$P_t = A \, Q_t^{B} R_t^{C} \qquad\qquad (C.3-1)$$

where:

P_t = unit price in year t

Q_t = cumulative quantity produced through year t

R_t = production rate in year t

Bemis estimated model parameters for 22 systems using multivariate and univariate linear regression. This was achieved by estimating lot midpoints and transforming the equation into its log-linear equivalent. The parameters identified by Bemis using this method are summarized in Table C.3-1. Bemis did not identify the systems by name.

TABLE C.3-1
BEMIS PRODUCTION RATE PARAMETERS

| System | Multiple Regression | | | Individual Regressions | | | |
| | | Rate | Quantity | Rate | | Quantity | |
	R	Slope	Slope	R	Slope	R	Slope
Aircraft A	.974	97.5	73.1	-.737	71.4	-.974	72.1
Aircraft B	.948	(4)	77.2	-.923	78.6	-.961	87.7
Aircraft C	.995	79.5	87.3	-.958	68.5	-.936	76.0
Aircraft D	.923	68.0	88.2	-.877	61.6	-.706	76.9
Aircraft E	.997	67.2	90.5	-.996	58.7	-.992	67.8
Aircraft F	.994	57.3	86.6	-.972	52.8	-.679	67.0
Aircraft G	.999	81.4	84.0	-.986	58.7	-.994	75.8
Aircraft H	.971	91.4	74.4	-.815	66.7	-.964	70.7
Aircraft I	.999	(5)	86.3	-.972	80.0	-.999	87.7
Aircraft J	.786	86.3	97.1	-.768	89.5	-.542	94.8
Helicopter	.997	89.3	83.8	-.875	81.9	-.996	83.1
Jet Engine A	.984	92.0	75.0	-.652	74.6	-.971	72.6
Jet Engine B	.988	89.5	71.4	-.477	76.3	-.970	69.8
Missile A	.974	(6)	65.1	-.925	52.5	-.974	66.0
Missile B	.873	(7)	82.3	-.463	84.2	-.851	85.4
Missile G&C	.981	90.7	(1)	-.820	89.4	+.684	(1)
Missile G&C	.996	59.4	91.9	-.990	62.8	-.820	60.0
Ordnance A	.964	97.0	88.1	-.622	93.2	-.932	86.6
Ordnance B	.979	(3)	97.5	+.588	(3)	-.972	76.6
Radar A	.990	88.8	93.1	-.902	86.0	-.765	87.7
Radar B	.890	91.6	98.9	-.870	88.8	-.784	94.7
Tracked Veh	.963	90.7	(2)	-.867	88.7	+.700	(2)

Where R = correlation coefficient

(1)--(8)   Slopes greater than 100%

C.4   BOHN AND KRATZ

Michal Bohn and Louis A. Kratz, "Analysis of Production
Rate Effects on Unit Costs," TASC, EM-228-WA,
January 1984.

Most recently Bohn and Kratz have presented a detailed

description of the production rate formulation employed by Kratz

and Cox in support of AMRAAM. The approach builds upon the

efforts of L. L. Smith and Bemis; however, it differs from prior

formulations in two respects:

- The concept incorporated increasing unit costs due
to increased production rates beyond a minimum
cost point, assuming a fixed plant.

● Parameters for the model were estimated using
  nonlinear techniques.

The Bohn and Kratz formulation places a limit on the
ability of a manufacturer to decrease unit costs through
production rate increases. The authors suggest that this
reflects defense procurement constraints, such as fixed
facilities, in the short run. The formulation is graphically
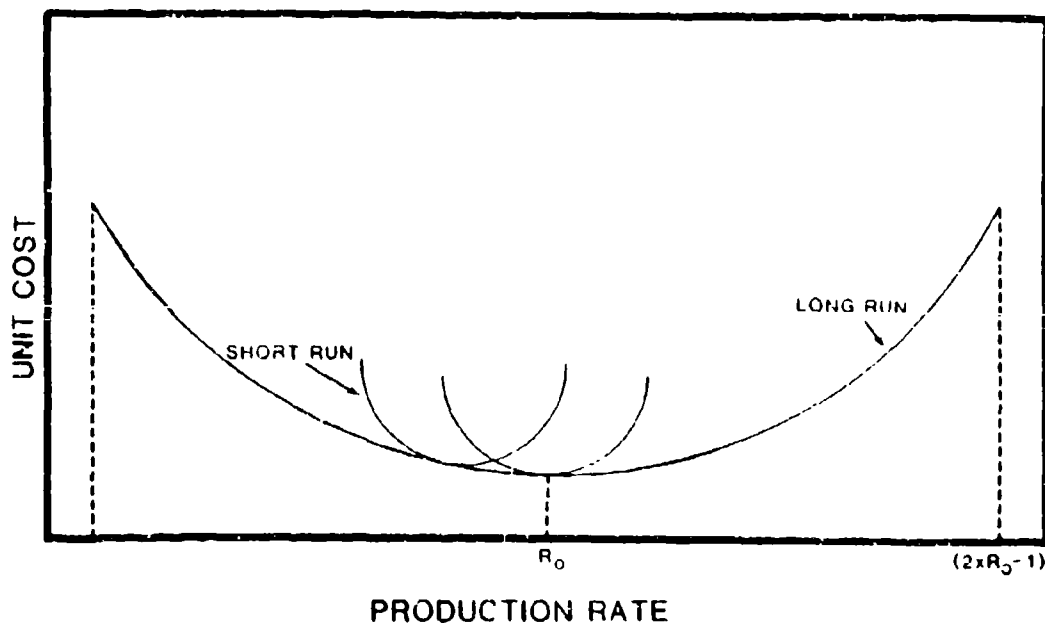presented in Figure C.4-1.

Figure C.4-1   Bohn and Kratz Production Rate Formulation

The formulation assumes the existence of a minimum cost
point, denoted R_0 in Figure C.4-1. The authors state the
R_0 rate is determined by a manufacturer prior to production.
They argue a manufacturer will arrive at this rate in an attempt
to minimize costs by considering facility limitations, capital
investment and manpower requirements, anticipated quantities and

C-5

rates to be procured by the government, and requirements specified by the government. In developing the formulation, the authors assume a given production technology, a given plant, and a constant indirect cost structure.

The authors recognize that a contractor may adjust his production process to increase capacity given a sufficient planning horizon. However, they note that it is unlikely that a contractor will expand or duplicate facilities based upon a one-time increase in annual quantity. The risk involved and the capital lead time associated with expanding a line would preclude this. Bohn and Kratz note that in the short run a firm may achieve surge by employing multiple shifts, hiring new workers, and taxing capital equipment. They argue that these actions tend to raise unit costs. The authors also suggest that a sustained production rate increase may lead to an expansion or duplication of the production line. Such an expansion could result in production rate increases being achieved with no increase in unit cost. Mathematically, the formulation is presented in equation C.4-1.

$$Z = AX^B Y^C \qquad\qquad (C.4-1)$$

Where:

Z = unit cost of the Xth item produced

A = constant (sometimes referred to as T_1 or first unit cost)

X = cumulative quantity produced

B = exponent which describes the slope of the quantity/cost curve

C = exponent which describes the slope of the rate/cost curve

$$Y = \begin{cases} R \text{ if } R \leq R_0 \\ 2 R_0 - R \text{ if } R_0 \leq R < 2R_0 - 1 \end{cases}$$

R = production rate in effect for a given lot

R_0 = minimum cost production rate assuming given facility

The other area in which the formulation differs from prior efforts is in the estimation of model parameters. The authors present two limitations of the standard log-linear regression approach:

- Bias associated with lot midpoint estimation

- Multicollinearity between the rate and quantity variable

To partially offset these limitations, the authors suggest a weighted least-squares estimation of the nonlinear function based on a generalization of Newton's method for finding the roots of an equation. The authors estimate parameters for several missile programs using this approach. The results are summarized in Table C.4-1.

TABLE C.4-1
BOHN AND KRATZ
PRODUCTION RATE PARAMETERS EVIDENCED ON PRIOR MISSILE PROGRAMS

System	Producer	Unit Cost Improvement Rate	Unit Cost Production Rate Parameter
BASIC HAWK	Raytheon	0.83	0.97
BULLPUP AGM-12B	Martin	0.82	1.00
TOW	Hughes	0.98	1.01
SIDEWINDER			
AIM-9L	Ford	0.91	0.75
	Raytheon	0.87	0.85
SIDEWINDER			
AIM-9B	General Electric	0.90	0.82
STANDARD	General Dynamics	0.80	0.96
MAVERICK	Hughes	0.86	0.88
REDEYE	General Dynamics	0.93	0.79

C.5   C. H. SMITH

Charles H. Smith "Production Rate and Weapons Systems Cost: Research Review, Case Studies and Planning Model," U.S. Army Procurement Research Office, Report No. APRO-80-05, November 1980.

Smith presents a detailed review of prior research efforts related to production rate effects on unit cost. Based on this review, Smith concludes that the exponential form is a useful approach when sufficient historical data is available. The author suggests that in the planning phases of a program, the exponential approach may not be appropriate.

Smith develops a simple formulation that segregates fixed costs from the nonrecurring production costs. The author argues that amortization of fixed cost should be considered distinct from other rate effects. The resultant formulation is shown in equation C.5-1.

$$C_t = \sum_{Q=K+1}^{M} AQ_t^B + F \qquad \text{(C.5-1)}$$

Where:

C_t = total cost of production in year t

Q_t = quantity produced in year t

A = recurring first unit cost

B = learning curve parameter

F = constant annual fixed costs allocable
    to the program

As presented in equation C.5-1, the Smith formulation expresses total production costs as a function of recurring and fixed cost. This is an intuitively appealing approach and it provides the program manager with a simple tool to be used early in a program. In the early phases of a program, the program manager can use estimated fixed costs for the fixed cost variable. The program manager should note the limitation of the assumed constant fixed cost.

C.6   GREER AND LIAO

Willis R. Greer and Shu S. Liao, "Cost Analysis for
Dual Source Weapons Procurement," Naval Postgraduate
School, October 1983.

Greer and Liao present a detailed investigation of production rate, capacity utilization, and unit price. Based on a statistical investigation, they suggest the use of capacity utilization rather than production rate as a predictor of unit price. The Greer and Liao formulation is shown in equation C.6-1.

$$F = k \; Q^a \; U^c \; e^{dM} \; e^{fN} \qquad\qquad (C.6\text{-}1)$$

Where:

P = average price for the buy

Q = midpoint quantity associated with a particular lot

U = smoothed utilization percentage for the industry

M = dummy variable equal to 1 if the buy was under dual source, zero otherwise

N = dummy variable equal to 1 if the competition was winner-take-all, zero otherwise

e = base of the natural logarithm

$k, \; a, \; c, \; d, \; f$ = parameters to be estimated

To identify the smoothed capacity utilization, Greer and Liao used a resistant time series smoother followed by a Hanning running average.

Greer and Liao compare the performances of the traditional production rate models to the performance of the new formulation. The formulations are estimated using both the mean and median values of the data set. The results of the parameter estimation for the original producer of the system are shown in equation C.6-2.

$$(C.6\text{-}2)$$

Median values, $P = kQ^{-0.278} \; U^{+1.250} \; e^{-0.201M} \; e^{-0.854N}$

Mean values, $\quad P = kQ^{-0.260} \; U^{+1.765} \; e^{-0.201M} \; e^{-0.854N}$

Greer and Liao estimate that the parameter estimates shown in equation C.6-2 are statistically significant. They interpret the results as an indication that capacity utilization directly affects unit price. Furthermore, the negative coefficients of the competition terms imply there is a downward price shift when competition is introduced.

Greer and Liao also estimate model parameters for the second producers; however, the capacity utilization parameter estimate was not significant. In investigating the model form, Greer and Liao included a production rate variable and found it to be nonsignificant in all but one case.

C.7   WOMER

Norman Keith Womer, "An Automated Airframe Production Cost Model," Proceedings of the 1983 Federal Acquisition Research Symposium, Williamsburg, Virginia, December 1933.

Womer presents a more detailed consideration of production rate and a more complex formulation than those employed in prior efforts. The formulation expresses airframe labor hour costs as a function of the following:

- Worker learning through experience
- Worker learning through training
- Speed of the production line
- Length of the production line

Womer expresses these factors in an exponential formulation that can be estimated using nonlinear least squares.

Model parameters estimated based upon the C-141 demonstrate a good fit with a reported R^2 of 0.69. Womer's formulation represents more of the realities associated with manufacturing than other formulations; however, the data requirements are extensive. Release dates, delivery dates, man-hours per aircraft, and other manufacturing data must be used to apply the model.

APPENDIX D

PROGRESS CURVES

D PROGRESS CURVES

Recurring production costs for defense weapon systems often are estimated using a progress or learning curve. The economic analysis presented in Chapter Four of this handbook employs progress curves to represent unit prices in a competitive environment. The purpose of this appendix is to provide the program manager with a more detailed discussion of the progress curve concept. This appendix presents the following:

- An introduction to progress curves
- Alternative formulations of the progress curve
- Unit progress curve formulation
- Use of the unit progress curve in production competition analyses

D.1 AN INTRODUCTION TO PROGRESS CURVES

The learning curve was first formulated by T.P. Wright in 1936 using airframe manufacturing experience.[1] In its most basic form, the learning curve reflects a reduction in required labor hours as cumulative production quantity increases. The convention used is to cite the percent reduction in required labor hours based on a doubling of the cumulative production quantity. This reduction is attributed to workers' "learning" or experience.

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[1] T. P. Wright, "Factors Affecting the Cost of Airplanes," _Journal of Aeronautical Science_, 3, 122-128, 1936.

In recent years, this basic formulation has been expanded by several authors.[2] The learning curve has been developed to incorporate other recurring costs associated with production. It has been observed that the recurring costs of production follow a pattern similar to that of labor hours; that is, an increase in cumulative quantity leads to a reduction in unit cost. For example, if production unit number 1,000 of a missile program costs $500,000 and the progress curve is 80 percent, one would predict unit number 2,000 to cost 80 percent of $500,000 or $400,000. This development has led different authors to use different terms, sometimes interchangeably, when discussing learning curves. Often used terms include "progress curve," "cost improvement curve," and "experience curve." A typical progress curve is shown in Figure D.1-1.
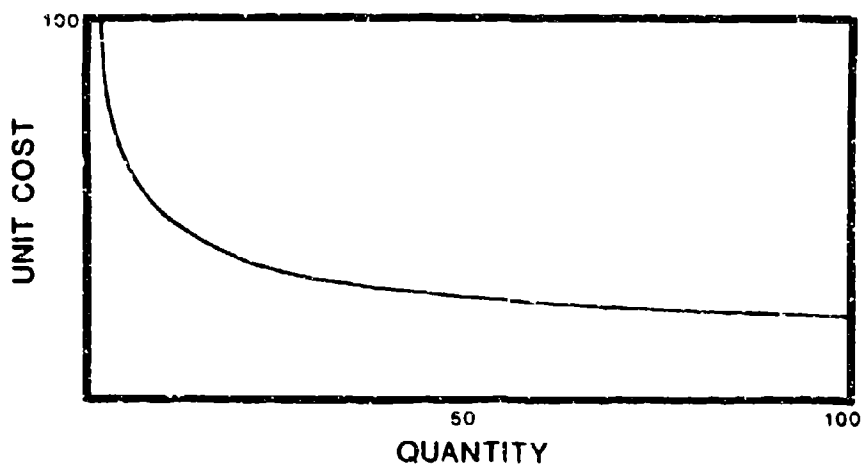

Figure D.1-1   Progress Curve

[2]See for example, Perspectives on Experience, Boston Consulting Group, 1968.

The term "progress curve" is used in this handbook to distinguish it from the learning curve. The latter implies reductions in labor hours due to worker learning. The progress curve includes all recurring costs, amortized capital cost, overhead, and profit. Thus, the progress curve presents the unit cost to the government (or contractor price).

It is important to note that the progress curve is descriptive in nature, not explanatory. The concept was developed using historical experience and empirical cost and quantity data. Empirical and theoretical studies have been undertaken recently to identify determinants of the progress curve. These studies have identified several factors, including the following:

- Increase in supervisory and employee familiarity with production methods

- Improvements in the production methods employed

- Improvements in fixtures, tooling, and machinery

- Development of more efficient handling and materials movement systems

- Overt management action such as product redesign

- Material substitution

- Shared production experience with similar production activities

- Reductions in scrap and waste

D.2   ALTERNATIVE FORMULATIONS OF THE PROGRESS CURVE

Two formulations of the progress curve have been used by DoD analysts: the cumulative average curve and the unit curve. The cumulative average curve formulation assumes that cumulative average costs decline by a constant percentage as the cumulative quantity of units produced increases. The unit curve assumes that the unit cost required to produce a specific unit declines by a constant percentage each time the cumulative quantity increases. In general use, the two forms are equivalent and the selection of one formulation over the other is determined by the particular analyst's needs, such as having a requirement for ease of computation.

The cumulative average curve formulation assumes that the cumulative average cost declines by a constant percentage as the cumulative quantity of units produced doubles. This can be mathematically presented as shown in equation D.2-1.

$$C_N = A \; N^B \qquad\qquad (D.2-1)$$

where:

C_N = the cumulative average cost at at the Nth unit

A   = a constant defined as the first unit cost

N   = the number of completed units

B   = an exponent of cost reduction defined as the in (progress rate)/ln(2)

The unit progress curve formulation assumes that the unit cost required to complete a specific unit declines by a constant percentage each time the cumulative quantity completed doubles. This can be mathematically presented as in equation D.2-2.

$$Y_N = AN^B \qquad\qquad (D.2-2)$$

where:

Y_N = the unit cost of the Nth unit

A = a constant defined as the first-unit cost

N = the number of completed units

B = the exponent of cost reduction defined as the ln (progress rate)/ln(2). Progress curve exponent values are provided on page D-11.

Although the two formulations are similar in notation, they present different cost relationships. The cumulative average formulation presents an average cost up to a given unit that is weighted by the cost of all prior units. The unit formulation presents a unit cost that is not influenced by the cost of prior units.

D.3   SELECTING A FORMULATION

The two formulations of the progress curve, although similar, present different characteristics. The selection of one formulation over another is determined by the needs and

requirements of the analyst. The cumulative average curve is used by some cost analysts, because of its ease of computation.

Although the unit curve is more cumbersome mathematically, this formulation is used by many analysts in assessing the costs and benefits of competition. This approach is used because it more readily reveals the dynamic aspects of the effect of competition on cost behavior in historical programs. By its nature, a cumulative average curve tends to mask changing cost behavior due to competition because the cumulative average cost of the competitive units is influenced by the costs of the prior noncompetitive units. This can be clearly seen in Figure D.3-1.
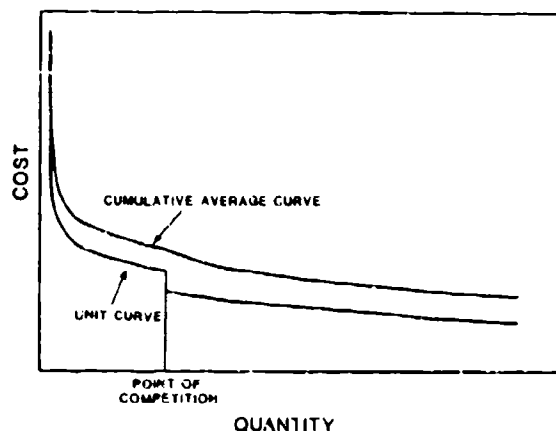

Figure D.3-1   Shift and Rotation Using Unit and Cumulative Average Curves

As shown in Figure D.3-1, the substantial shift and rotation of the unit curve manifest themselves as a slight rotation of the cumulative average curve. Attempting to fit a cumulative average curve through such data would tend to lessen the observed effects of competition.

By transferring the progress curves into their log-linear form, one can see the rotation of the cumulative average curve as shown in Figure D.3-2.

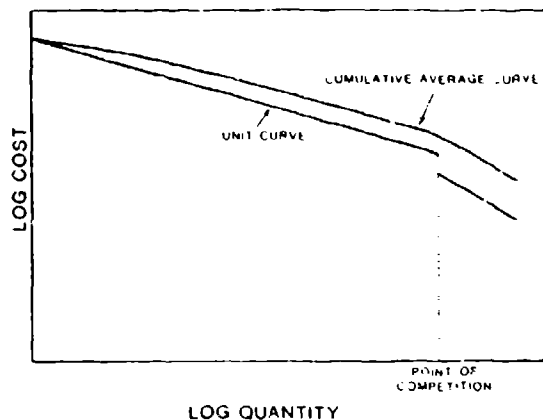
LOG QUANTITY

Figure D.3-2   Shift and Rotation, Unit and
                Cumulative Average Log-Linear Presentation

D.4   THE UNIT PROGRESS CURVE FORMULATION

The unit progress curve formulation presents the cost of each unit in a particular production run. Thus, the total cost of a production run can be estimated by summing up all of the individual unit costs. The unit cost progress curve formulation is given by equation D.4-1.

$$Z = A \ X^B \qquad (D.4-1)$$

Where:

Z = unit cost of the item number X

A = first unit cost

X = cumulative quantity produced

B = exponent which describes the slope
    of the progress curve, defined
    as the ln (progress rate)/ln(2)
    Progress curve exponent values are
    provided on page D-11.

D-7

The single source cost can be estimated by summing up all individual unit costs associated with a given production run. This is summarized in equation D.4-2, assuming N units produced.

$$\text{Total Cost} = Z_1 + \ldots\ldots + Z_N \qquad (D.4\text{-}2)$$
$$= A1^B + A2^B + A3^B + \ldots + AN^B$$
$$= A \, [1^B + 2^B + 3^B + \ldots N^B].$$

Equation D.4-2 adds the unit costs of all units produced from unit number K to unit number N. The total number of units produced is N-K+1. For example, if one were interested in estimated costs of the total production quantity, K would be 1 and N+1 would be the total number produced. If one were interested in estimating the cost of a particular lot, K would be the number of the first unit in the lot and N would be the number of the last unit. Combining equations D.4-1 and D.4-2 and calculating the total cost from unit K through N yields:

$$\text{Total Cost} = A[K^B + (K + 1)^B + \ldots + N^B] \qquad (D.4\text{-}3)$$
$$= \sum_{X=K}^{X=N} A(X)^B$$

The program manager could calculate the total costs for any number of units, then repeat the process for a different production lot, also for any number of units. However, this process would be laborious and time consuming, even if the equations were computer based. Fortunately, the program manager can simplify the computations by noting that the progress curve

is a continuous function. Thus, the area under the curve is the total cost for a given number of units produce1, as illustrated by Figure D.4-1.
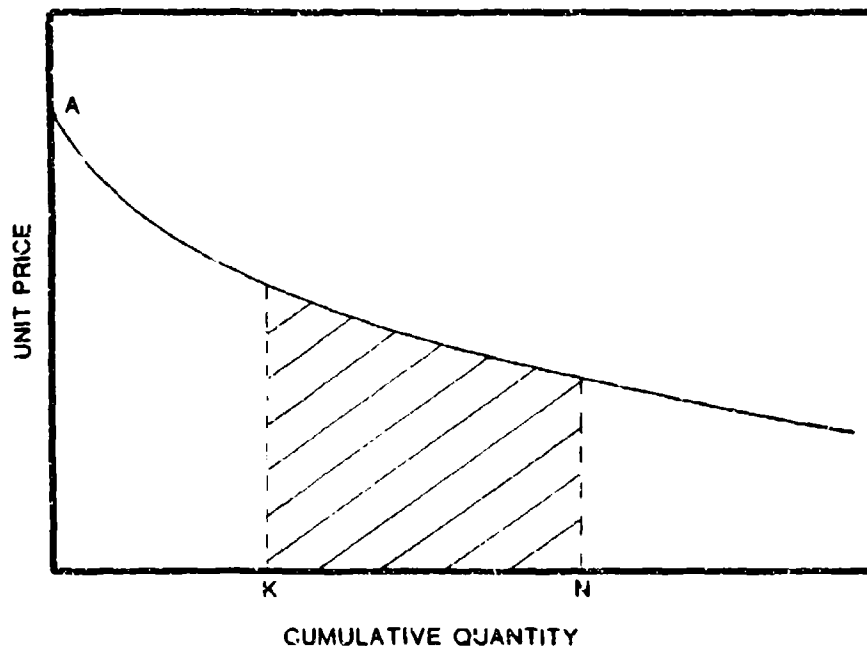

Figure D.4-1   Recurring Production Costs

As the number of units produced increases, the unit cost declines, based upon the progress curve formulation. The unit-cost curve is derived from equation D.4-1, based upon the progress exponent, B. The curve crosses the vertical axis at point A, the first-unit cost. The total cost of producing N-K+1 units is the shaded area, which shows the cost curve from unit to unit N.

Using this approach, the total cost may be found by using integral calculus to estimate the shaded area. The general equation is easy to use and provides a good approximation of the

cost that would be obtained by performing a unit-by-unit calculation. The integral equation is shown in equation D.4-4.

$$C(K,N) = \int_{K}^{N} AX^{B} \qquad \text{(D.4-4)}$$

$$= \frac{A}{B+1} \left[N^{B+1} - K^{B+1} \right]$$

where: $C(K,N)$ = the cost of producing all units from K through N. Thus, the total units produced in a lot = N - K + 1.

A = first unit cost

B = ln(progress rate)/ln(2)

To illustrate equation D.4-4, assume that first-unit cost is $10,000 and the progress rate is 90 percent. The cost of the third production lot, which begins at unit 155 (=#K) and continues to unit 210 (=#N), would be estimated as shown in equation D.4-5.

$$C(155,210) = \frac{\$10,000}{0.848} \left[210^{.848} - 155^{.848} \right] \qquad \text{(D.4-5)}$$

$$= \$11,792 \ [93.16 - 72.01]$$

$$= \$249,401$$

A total of 56 units are produced (N-K+1 = 56) at an average price of $4,454. The substantial decline in price from the first unit price of $10,000 is due to the progress function. In fact, the final unit price (N=210) would be as shown in equation D.4-6.

$$C(210) = \$10,000 \ (210)^{-.152} \qquad \text{(D.4-6)}$$

$$= \$ 4,436$$

To assist the program manager in calculating recurring costs using the progress curve, Table D.4-1 presents the exponent values (B) associated with common progress curve rates.

TABLE D.4-1
PROGRESS CURVE EXPONENTS

Progress Curve	Exponent (B)
95%	-.074
90	-.152
85	-.234
80	-.322
75	-.415
70	-.515
65	-.621

APPENDIX E

EXAMPLE ECONOMIC ANALYSIS

E EXAMPLE ECONOMIC ANALYSIS

The economic analysis of production competition discussed in Chapter Four is illustrated in this appendix. The example will rely upon the net present value method to emphasize the interaction of the variables and to highlight the use of sensitivity analysis.

E.1 SINGLE SOURCE RECURRING PRODUCTION COSTS

This example involves a major tactical missile program. Based on contractor and historical data, a first unit cost of $750,000 in constant FY86 dollars has been estimated. The progress curve, including profit and overhead, is projected to be 0.88. A production rate curve of 0.95 has been identified based upon a should-cost study. A total buy of 12,000 missiles is anticipated to begin in FY86, according to the production schedule presented in Table E.1-1.

TABLE E.1-1
TACTICAL MISSILE PRODUCTION SCHEDULE

Fiscal Year	86	87	88	89	90	91	Total
Quantity	500	1,000	1,500	3,000	3,000	3,000	12,000

Single source recurring production costs by lot are estimated
using the progress curve formulation presented in equation E.1-1.

$$C\ (K,N) = \frac{A}{B+1} \left[N^{B+1} - K^{B+1}\right] R^C \qquad (E.1-1)$$

where:

$C(K,N)$ = the recurring production cost of all units from K through N

A = first unit cost = \$750,000

B = ln(progress curve rate)/ln(2) = ln(88)/ln(2) = -.184

R = production rate per period = annual procurement quantity

C = ln(production rate parameter)/ ln2 = ln(.95)/ln(2) = -.074

Notice that the rate factor (R^C) is treated as a parameter in
that it takes the same form in the total cost curve above as it
does in the unit cost curve equation. The rate, R, assumes a
fixed value for a particular period. For example, the single
source cost for the first lot can be calculated as shown in
equation E.1-1.

The recurring production costs associated with each lot are presented in Table E.1-2.

TABLE E.1-2
ESTIMATED SINGLE SOURCE RECURRING PRODUCTION COST

Fiscal Year	Quantity	Recurring Cost in Millions of FY86 Dollars
86	500	93.5
87	1000	133.4
88	1500	163.2
89	3000	273.0
90	3000	248.0
91	3000	232.6
Total	12000	1143.7

E.2   NONRECURRING COSTS

A total nonrecurring investment of 65 million constant FY86 dollars is estimated based upon anticipated tooling requirements and equipment complexity. These costs include: contractor research and development, technology transfer, production qualification of the second source, additional capital and test equipment, and additional government management. These costs are incurred as $10 million in FY85, $25 million in FY86, and $30 million in FY87.

E-3

E.3 COMPETITIVE RECURRING PRODUCTION COSTS

It is anticipated that the second source will be awarded directed buys in FY87 and FY88. Competitive awards will begin in FY89. A 60/40 split is assumed. The following progress curve characteristics also are assumed:

- First unit cost for both the first and second source equals $750,000.

- An original progress rate of 0.88 for the first source.

- A progress rate of 0.84 for the second source (5% steeper).

- A ten percent shift and an eight percent rotation of the developer's progress curve at the beginning of competitive awards.

- A 0.95 production rate curve for both producers.

Table E.3-1 presents the competitive production schedule.

TABLE E.3-1
COMPETITIVE PRODUCTION SCHEDULE

Fiscal Year	Quantity	
	Developer	Second Source
86	500	0
87	700	300
88	900	600
89	60/40 split ⎰	3000
90	⎱	3000
91		3000
Total	12000	

The program manager must estimate the cost of both producers. The first step would be to estimate the costs of the directed buys (FY86 to FY88) using equation E.1-1. For example, the cost of the second source initial lot would be calculated as shown in equation E.3-1.

$$C(1,300) = \frac{750,000}{.75} \left[300^{.75} - 1^{.75} \right] (300)^{-0.75} \qquad \text{(E.3-1)}$$

$$= (71.1)\ (.67)$$

$$= 47.6 \text{ Million}$$

The cost of the first and second source directed buys can be summed to yield total lot cost per fiscal year. The program manager then must estimate the cost under competition. The initial producer's cost can be estimated using the competitive production progress curve. That is the original producer's curve following the shift and rotation. The second source's cost can be estimated by continuing down the stated progress curve.

The issue the program manager must face is the production quantities to be awarded to the two contractors. The program manager cannot presume a winner of the competition; thus, the quantities awarded to the contractors cannot be identified and costs cannot be calculated. It is suggested that the program manager identify a "probable" winner based on the stated assumptions. This can be accomplished by comparing the average lot cost of both competitors for the larger portion. The low cost producer would be identified as the winner. The sensitivity of the competition outcome to changes in the "probable" winner can be investigated by altering the assumptions concerning the second source progress rate and the initial producer's shift and rotation. This method maintains a consistent pattern for

sensitivity analysis and ensures the economic analysis remains internally consistent.

A summary of recurring competitive production costs for the stated example are presented in Table E.3-2.

TABLE E.3-2
RECURRING COMPETITIVE PRODUCTION COSTS

| Fiscal Year | Quantity | | Recurring Cost in Millions of FY86 Dollars |
	Developer	Second Source	
86	500	0	93.5
87	700	300	143.4
88	900	600	165.7
89	60/40 split { 3000		234.9
90	3000		202.1
91	3000		184.2
Total	12000		1023.8

Estimated recurring cost savings can be obtained by comparing the annual single source and competitive costs. For the stated example, these savings are shown in Table E.3-3.

TABLE E.3-3
PROJECTED RECURRING PRODUCTION COST SAVINGS

Fiscal Year	Quantity	Millions of FY86 Dollars		
		Single Source Cost	Competitive Cost	Potential Savings
86	500	93.5	93.5	---
87	1000	133.4	143.4	-10.0
88	1500	163.2	165.7	-2.5
89	3000	273.0	234.9	38.1
90	3000	248.0	202.1	45.9
91	3000	232.6	184.2	48.4
Total	12000	1143.7	1023.8	119.9

E.4   GOVERNMENT ADMINISTRATIVE COSTS

In addition to contractor production costs, the program manager must consider additional government management and administration costs associated with competitive production. These include additional personnel and facilities to conduct solicitation, selection and award of competitive contracts, follow-on lot acceptance test, and the continuing management of two contractors. For this example, additional government management costs during production are estimated to be $0.5 million per year. No additional support costs are assumed.

E.5 INTEGRATION OF COST ELEMENTS

The program manager must integrate the various cost elements in order to make an investment decision. In reaching this decision, the program manager is reminded of the importance of discounting future costs and benefits. For convenience the net present value formulation applicable to production competition is shown again in equation E.5-1.

NPV = Present value of cost reduction -
present value of nonrecurring costs   (E.5-1)

$$NPV = \sum \frac{CR_i}{(i+r)^i} - \sum \frac{NR_i}{(i+r)^i}$$

where: NPV = net present value of competition investment

       CR = net cost reductions due to competitive production in year i

       NR = nonrecurring costs incurred due to competitive production in year i

       R = discount rate, set at 10 percent

The formulation presented in equation E.5-1 yields the discounted net present value of production competition for a particular program. The example costs and benefits expressed in constant dollars should be discounted back to fiscal year 1985, the first year of investment. Discounted nonrecurring costs are shown in Table E.5-1.

TABLE E.5-1
DISCOUNTED NON-RECURRING COSTS

Fiscal Year	Millions of Dollars	
	Constant FY86	Discounted
85	10.0	10.0
86	25.0	22.7
87	30.0	24.7
Total	65.0	57.4

The net potential recurring savings associated with
production competition can be obtained by subtracting additional
recurring government management costs from the potential
production savings identified in Table E.3-3. This process and
the discounted net potential recurring savings are presented in
Table E.5-2.

TABLE E.5-2
DISCOUNTED POTENTIAL SAVINGS

Fiscal Year	Net Savings in Millions of Dollars Constant FY86	Discounted
86	---	---
87	-10.5	-8.7
88	-3.0	-2.3
89	37.6	25.7
90	45.4	2C.2
91	47.9	27.1
Total	117.4	70.0

As shown in Tables E.5-1 and E.5-2 the discounted costs and benefits of production competition are $57.4 million and $70.0 million respectively. This indicates a net present value of $12.6 million.

Discounting future costs and benefits is an important management tool that enables the program manager to assess the effect of production competition while taking account of the time

value of money. Equally important is the effect of production
competition on then year (or budget year) dollars. Table E.5-3
presents single source recurring production costs and total
competitive production costs in then year, constant, and
discounted dollars. A constant six percent inflation rate was
used to calculate then year dollars.

TABLE E.5-3
POTENTIAL SAVINGS

Production Approach	Millions of Dollars		
	Discounted (from constant FY86)	Constant FY86	Then Year
Single Source	785.6	1143.7	1371.5
Competitive	773.0	1091.8	1285.2
Potential Savings	12.6	51.9	86.3

E.6   SENSITIVITY ANALYSIS

        Analyses are conducted to investigate the
sensitivity of the net present value calculations to changes in
key assumptions. This is accomplished by altering the various

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assumptions one at a time. In regard to production competition, the key assumptions are the following:

- Total planned quantity

- Initial progress curve

- Shift and rotation parameters

- Year of the first competitive award (or point in the production cycle)

The relationship between these factors and the production competition decision are discussed and illustrated using the example tactical missile.

Total Quantity

This sensitivity investigation can be characterized as a break-even analysis. By analyzing cumulative single source recurring cost, cumulative competitive recurring cost, and nonrecurring investment, the program manager can identify the break-even quantity. This quantity is the cross-over point of the single source cost curve and competitive cost curve shown in Figure E.6-1.
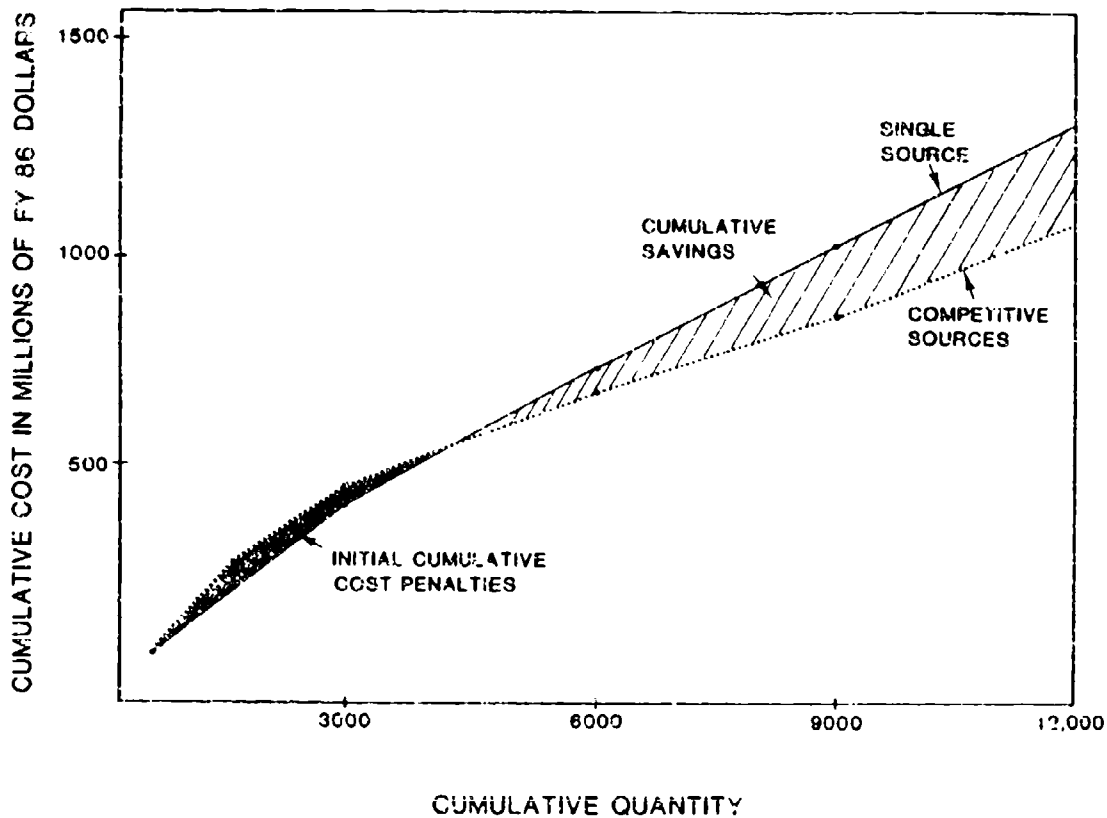
Figure E.6-1   Total Quantity Sensitivity

Quantity increases beyond the break-even point enhance the

attractiveness of competitive production. If total quantity is

expected to be reduced to, or below, the break-even quantity,

caution should be exercised. This is particularly true for major

subsystem programs, whose total quantities are determined by

their associated system programs.

Progress Curve

Prior to production, the progress curve for the
tactical missile was estimated based upon DoD experience with
similar systems and contractor data. Therefore, the sensitivity
of the competition decision to changes in the projected progress
curve should be investigated.

Prior empirical studies have demonstrated that greater
recurring cost savings are associated with flatter initial
progress curves. This is shown in Figure E.6-2. The single
source progress curve is also the assumed initial progress curve
for the developer. All other parameters remain unchanged.
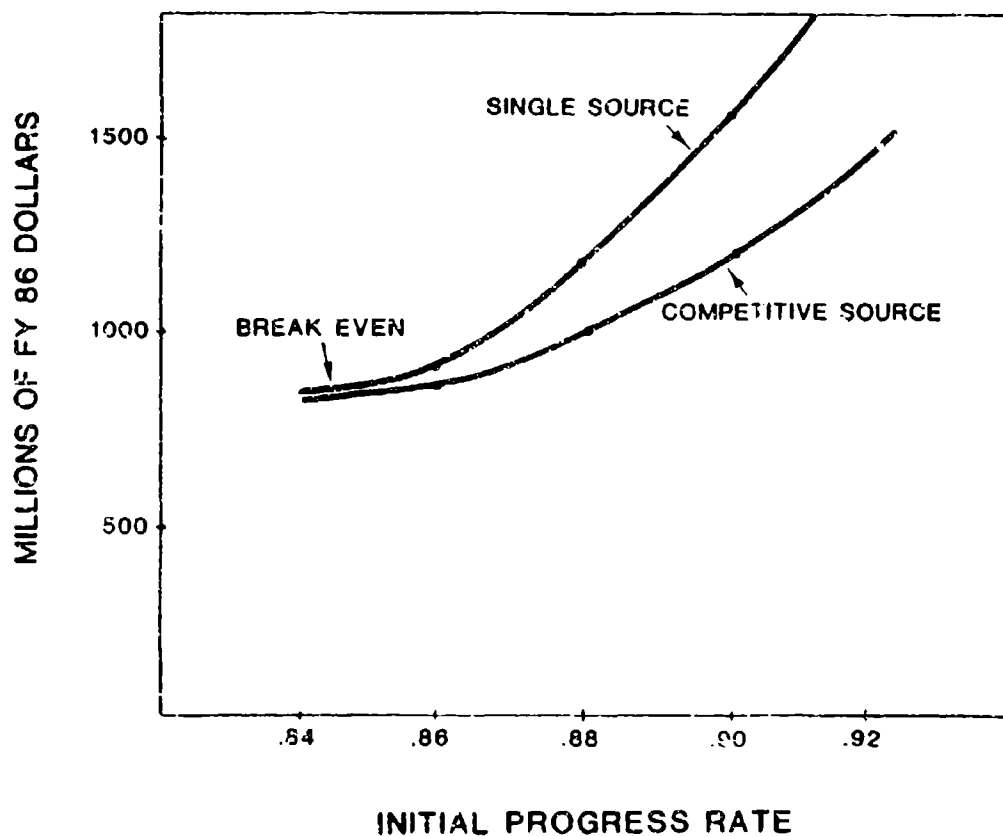
Figure E.6-2   The Sensitivity of Recurring Costs to Initial
                Progress Curve

Figure E.6-2 demonstrates the sensitivity of the production competition decision to changes in the assumed single source progress curve. Another significant factor is the assumed second source progress curve. The empirical evidence indicates a wide variation in steepness for tactical missiles. In addition, this steeper curve is taken as an assumption, rather than being estimated from prior data. Therefore, sensitivity analysis is particularly important.

As expected, the steeper the second source progress curve is, the greater is the potential savings due to competitive production. This is shown graphically in Figure E.6-3.
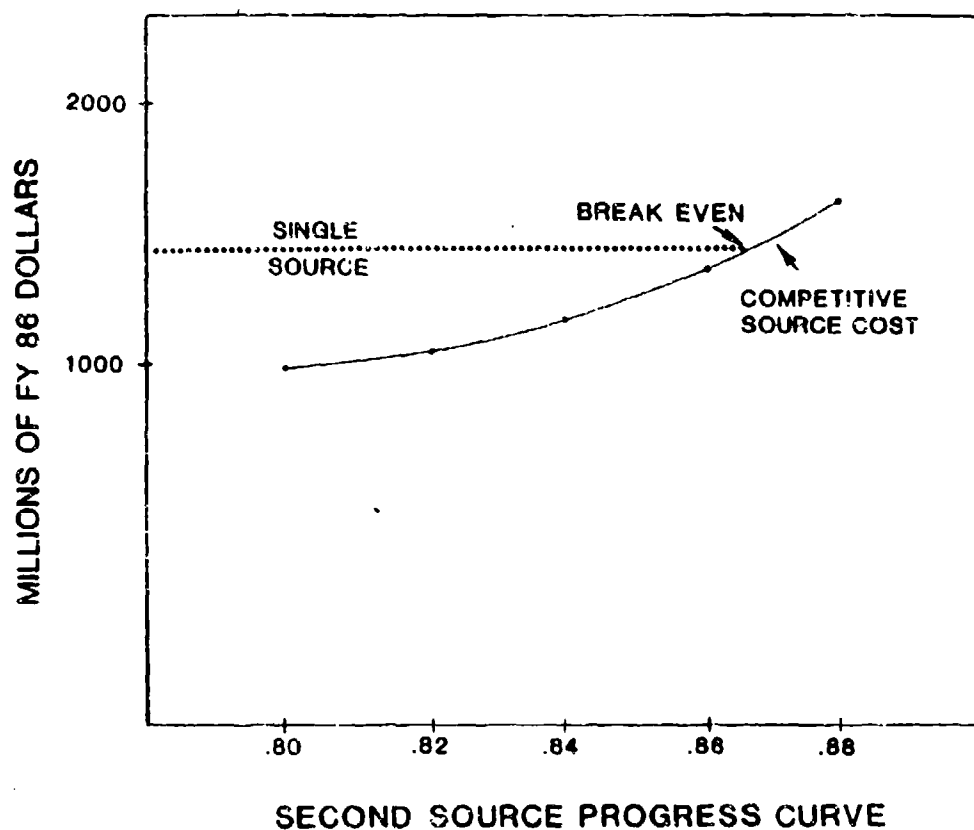

Figure E.6-3   The Sensitivity of Recurring Cost to Second
                  Source Progress Curve

Shift and Rotation

Sensitivity analyses on the shift and rotation parameters are important due to the dispersion and limitations of this historical data. The greater the assumed shift or rotation, the greater would be the potential savings. More detailed analysis is necessary to identify the minimum shift and rotation

necessary to balance the costs of establishing the competitive source.

If the required break-even shift and rotation parameters are beyond the historically observed range, production competition may not be economically beneficial. If potential savings are projected even when using conservative assumptions, production competition may be promising.

Figure E.6-3 presents recurring competitive production costs for changing shift and rotation parameters, again based upon the prior example. The curve labeled "ROTATION" presents competitive production costs using various rotations and assuming a constant shift of ten percent. Similarly, the curve labeled "SHIFT" presents competitive production costs using various shift values and assuming a constant rotation of eight percent.
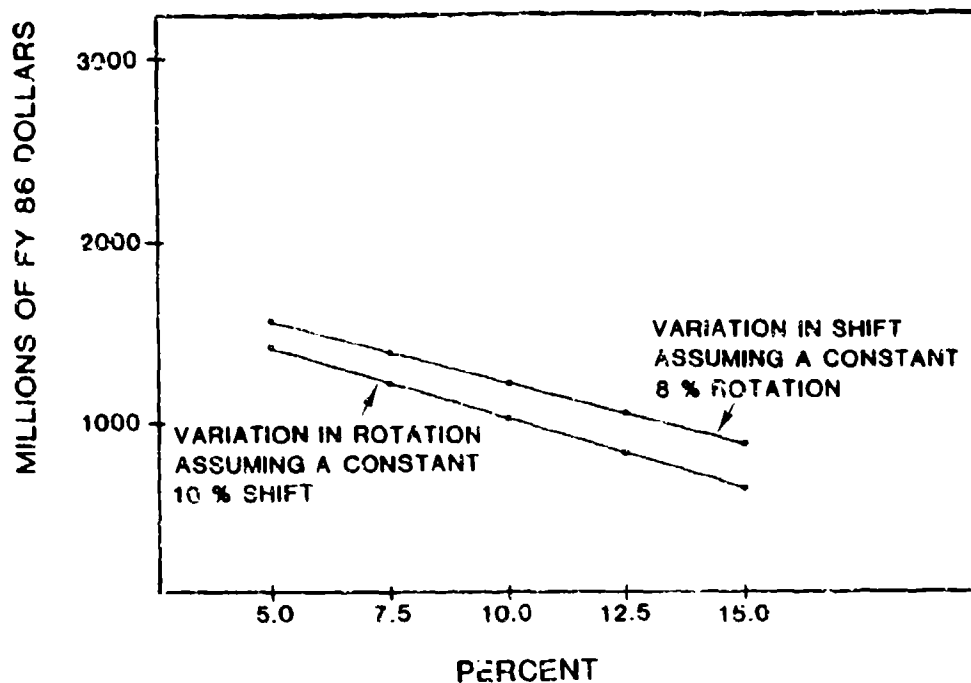
Figure E.6-4   The Sensitivity of Competitive Recurring
                Cost to Shift and Rotation

Figure E.6-4 illustrates that, for the example,
reasonable assumptions concerning shift and rotation lead to
potential savings due to competitive production.

First Competitive Award

The timing of the first competitive award is a critical
decision variable for any production competition program due to
its direct relationship to the selection of a technology transfer
method and break-even analysis. Prior analyses have established
that greater potential savings can be obtained by initiating

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competitive awards earlier in the production program. The ability of the program manager to conduct early competitive awards is largely a function of the technique used to effect technology transfer. For example, a TDP technique may enable competitive awards to begin in the fourth year of production. By initiating technology transfer during FSD, through teaming or a leader-follower approach, the program manager may be able to achieve competitive production awards in the second or third year of production.

Early competitive awards may be difficult to achieve, since early second source involvement may be precluded by constrained near-term funding. In such a situation, the program manager must identify the break-even point. If second source development and competitive production must be delayed, the point at which competition is no longer economically viable should be identified. For example, if effective technology transfer cannot be achieved until the fifth year in production, competition may not be economically attractive.

Figure E.6-5 presents the sensitivity of recurring competitive production costs to the timing of the first competitive award. As shown, recurring competitive production costs increase as the initial competitive award is delayed.
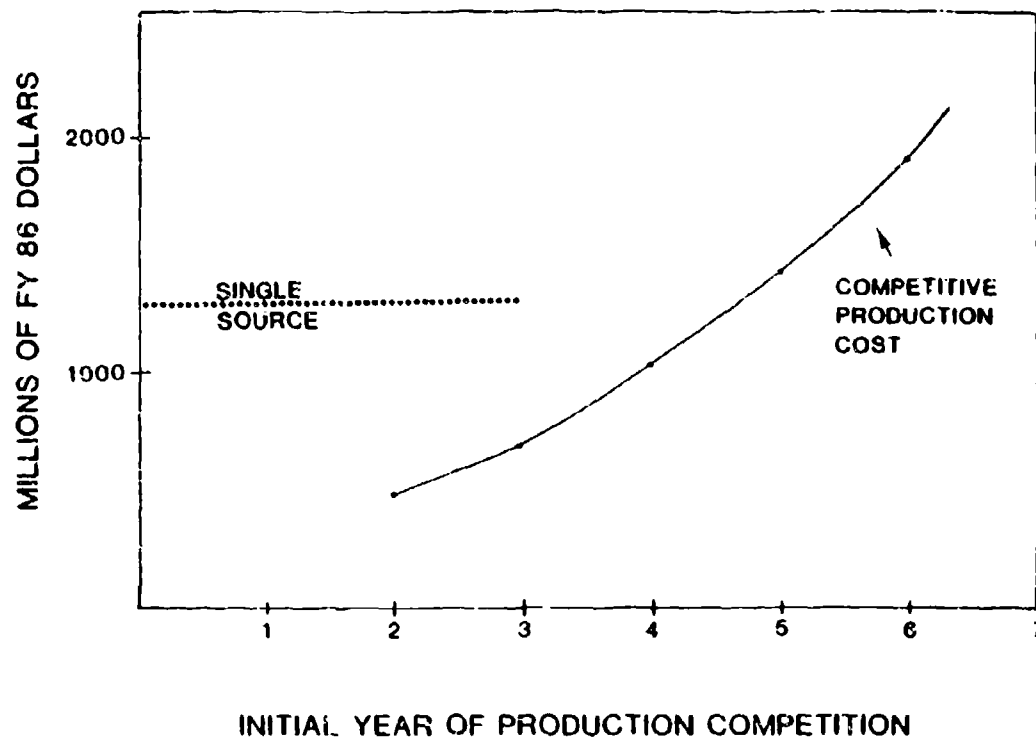
Figure E.6-5   The Timing of Competition

APPENDIX F

OFPP POLICY LETTER 84-2

FEB 27 1984

TO HEADS OF EXECUTIVE DEPARTMENTS AND ESTABLISHMENTS

FROM: DONALD E. SOWLE

SUBJECT: Policy Letter on Noncompetitive Procurement Procedures

The attached policy letter implements the President's August 11, 1983 memorandum (attached) requiring the issuance of policy direction to restrict the use of noncompetitive procurement procedures. This policy is an essential element of the President's Reform '88 Management Improvement Program and will help agency heads to assure that competition is the preferred method of procurement. In addition to establishing a finite list of circumstances under which noncompetitive procurements must be justified, the policy letter requires that the procurement regulatory agencies (DOD, GSA & NASA) publish tight controls over noncompetitive procurements in the Federal Acquisition Regulation and that the Agency Senior Procurement Executive establish internal procedures for review and approval of the justifications for noncompetitive procurements.

In addition to these controls, the Federal Procurement Data System will be amended for the purpose of collecting information on the use of each of these circumstances to justify a noncompetitive contract. Uniform data collection on the extent of noncompetitive procurements and the reasons therefor will both help to control excessive noncompetitive awards and promote an understanding of the need for and extent of valid noncompetitive procurements.

The Office of the United States Trade Representative expressed concern that the implementation of this policy letter be in compliance with the Trade Agreements Act of 1979. Representatives from DOD, GSA, NASA and the USTR met at OFPP where the intent of this policy letter was explained in detail. In response to the concerns of the USTR, the procurement regulatory agencies shall assure that the requirements of the Trade Agreements Act of 1979 and Executive Order 12260 are incorporated in the implementation of this policy letter in the FAR. In developing such implementation the regulatory agencies should work with the Office of the United States Trade Representative to assure accomplishment of this objective.

A "Competition In Contracting Act" is pending which addresses the same subject as this policy letter. Pending enactment of any such legislation, this policy letter establishes the Administration's policy on noncompetitive procurement procedures.

Attachment

F-1

OFFICE OF FEDERAL
PROCUREMENT
POLICY

FEB 27 1984

OFPP POLICY LETTER NO. 84-_

TO THE HEADS OF EXECUTIVE DEPARTMENTS AND ESTABLISHMENTS

Subject: Noncompetitive Procurement Procedures

1.   **Purpose.**   The purpose of this Policy Letter is to establish uniform restrictions on the use of noncompetitive procurement procedures.

2.   **Background.**   Both the Armed Services Procurement Act (ASPA) and the Federal Property and Administrative Services Act (FPASA) require that procurements be competitive to the maximum practicable extent.   However, approximately one-third of procurement dollars today ($56B in FY' 83) are awarded without obtaining competition   (This does not include procurements reported as "follow-on after competition" $31B in FY '83.)   One of the principal goals of the Administration's Proposal for a Uniform Federal Procurement System, submitted to Congress on February 26, 1982, is to increase competitive procurements where practicable.   Executive Order 12352, Federal Procurement Reforms, March 17, 1982, also highlights enhancing competition and limiting noncompetitive procurement actions as key elements of procurement reform.

In his memorandum of August 11, 1983 to the Heads of Executive Departments and Agencies (attached), President Reagan directed that competition be given preference in agency buying programs.   He also directed the Administrator for Federal Procurement Policy to issue a formal policy directive establishing Government-wide restrictions on the use of noncompetitive procurement.

It is important that we obtain the benefits of competition -- economic, technological and managerial — to the maximum practicable extent.   This policy letter focuses existing agency direction more effectively and requires procurement officials to take greater advantage of competitive opportunities.

Although the primary purpose of this policy letter is to establish controls on the use of noncompetitive procurement procedures, the heads of executive departments and agencies should also 1) communicate to department or agency program and procurement personnel a strong commitment to competition; 2) promote advance procurement planning, market research and early communication between program and procurement personnel to identify opportunities for competition early in the acquisition cycle; 3) strictly enforce the requirement for complete justification of noncompetitive procurements and careful scrutiny by review officials; 4) take reasonable steps, where competition is impracticable, to remove or overcome barriers to competition for subsequent procurements; 5) provide appropriate training; and 6) use data systems to track noncompetitive procurements and progress toward increasing competition.

3. Policy.

a. For procurements of property or services over the small purchase ceiling, competitive procedures shall be used unless one or more of the following circumstances require the use of noncompetitive procedures:*

(1) The property or service needed by the Government is available from only one source and there is no competitive alternative nor can competitive alternatives be developed in time to satisfy the requirements of the Government.

(2) The property or service needed by the Government is urgently required under unusual and compelling circumstances, caused by other than a lack of advance planning or funding concerns.

(3) An award must be made to a specified source or sources —

(i) when it is necessary to (A) maintain a facility, producer, manufacturer, or other supplier available for furnishing property or services in case of a national emergency, (B) achieve industrial mobilization in the case of such an emergency, or (C) maintain an essential research capability to be provided by an educational or other nonprofit institution or a Federally Funded Research and Development Center;

(ii) to establish or maintain an alternative source which will likely increase or maintain competition and will likely result in lower overall cost to the Government;

(iii) for follow-on procurements, in order to avoid (A) substantial duplication of cost to the Government for the property or service being procured, which cannot be expected to be recovered through competition or (B) unacceptable delays in accomplishing the agency's mission objectives;

(4) The contract to be awarded results from acceptance of a bona fide unsolicited proposal that meets the requirements set forth in 3.d. below and that demonstrates a unique or innovative concept

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*The application of this policy letter to procurements above the small purchase ceiling does not mean that small purchases need not be competitive. It is expected that the FAR will continue to require competition and justification of noncompetitive small purchases above a minimum dollar amount that is administratively cost effective.

which fills a requirement or general mission need of the Government (the term "unsolicited proposal" means a proposal that is submitted to a Federal department or agency on the initiative of the submitter for the purpose of obtaining a contract with the U.S. Government, and which is not in response to a formal or informal request (other than a departmental request constituting a publicized general statement of need in areas of science and technology-based research and development that are of interest to the department)).

(5) A specific source is required by international agreement or for directed procurements for foreign governments.

(6) The property or service is authorized or required by statute to be obtained from or through another Federal agency, or required by statute to be obtained from a specified source.

(7) Disclosure of the property or service needed by the Government to more than one source would jeopardize the national security.

b. Justification for a noncompetitive procurement which does not fall under any of the circumstances listed in 3.a. above, shall be reviewed and approved by the Department or Agency Senior Procurement Executive and may not be delegated.

c. Regulations and procedures to ensure that noncompetitive procurements awarded under the circumstances listed in 3.a. above are tightly controlled shall be published in the Federal Acquisition Regulation (FAR). The contracting officer shall justify, in writing the proposed use of noncompetitive procurement procedures and shall ensure that the information has been certified as accurate by the requiring activity. The justification shall be retained in the contract file. In accordance with P.L. 98-72 and regulatory direction in the FAR, the Agency Senior Procurement Executive (required by E.O. 12352 and P.L. 98-191) shall establish procedures for review and approval of such justifications.

d. Following regulatory direction in the FAR and the requirements of P.L. 98-72, the Agency Senior Procurement Executive shall establish procedures to assure that contract awards under circumstance 3.a.(4) result from bona fide unsolicited proposals and that such proposals are not the result of actions by Government personnel which circumvent the requirement to effect competition to the maximum extent practicable. (This is not intended to prevent "advance guidance" such as that presently contained in FAR 15.5 or broad agency announcements constituting general statements of need in areas of science and technology based research and development that are of interest to the agency.)

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e. The extension of a management and operating contract shall be awarded in accordance with FAR 17.6.

This additional attention to noncompetitive procurements will further the implementation of Executive Order 12352 as part of the procurement reforms being carried out in accordance with Reform 88 and the Administration's Proposal for a Uniform Federal Procurement System. It is important to note that the policies contained in this Policy Letter are not intended to adversely affect such congressionally-mandated programs as those dealing with small, minority and disadvantaged businesses, small business innovation research, or such Presidential initiatives as those dealing with the establishment of minority business goals.

4. Effective Date. This policy will be effective when implemented in the Federal Acquisition Regulation (FAR). The Department of Defense, the General Services Administration and the National Aeronautics and Space Administration shall ensure that this policy is implemented in the FAR no later than 120 days after the date of this policy directive.

Donald E. Sowle
Administrator

THE WHITE HOUSE

WASHINGTON

August 11, 1983

MEMORANDUM FOR THE HEADS OF DEPARTMENTS AND AGENCIES

SUBJECT: Competition in Federal Procurement

Competition is fundamental to our free enterprise system. It is the single most important source of innovation, efficiency, and growth in our economy.

Yet, far too often the benefits of competition are excluded from the Federal procurement process -- a process which now results in expenditures of over $160 billion annually. Numerous examples of waste and exorbitant costs due to the lack of competition have been detailed by the Congress and the press during recent months.

Although efforts have been initiated by this Administration through the Reform '88 Management Improvement Program to correct this longstanding problem, I am convinced that more needs to be done. Consequently, I have directed Don Sowle, the Administrator for Federal Procurement Policy in the Office of Management and Budget, to issue a policy directive on noncompetitive procurement to all departments and agencies. That policy directive will establish government-wide restrictions on the use of noncompetitive procurement and will be reflected in the government's procurement regulations. While such congressionally mandated programs as contracting with minority firms and handicapped persons will not be affected, the unwarranted use of noncompetitive practices must and will be curtailed.

Pending the formal issuance of this new policy by the Administrator, I call upon each of you to assure that competition is the preferred method of procurement in your department or agency.

Ronald Reagan

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Comment Sheet
for
Establishing Competitive Production Sources

Because the challenges related to production competition are complex and some of the techniques described in this handbook are relatively new, revisions to this handbook may become necessry as additional experience and data become available. A major consideration during the preparation of possible subsequent editions will be the comments, criticisms, or suggestions of you, the handbook's users. Use the space below to let the editors know how you think this handbook can be improved (e.g., recommended additions, deletions, corrections, or other suggestions). Attach additional sheets as necessary.

Whether or not you have comments or suggestions for future editions, we are very interested in your reaction to our efforts on this handbook. Please take a few moments to identify its strengths and weaknesses. In each box, enter a number rating as follows: 1-Excellent; 2-Good; 3-Fair; 4-Poor.

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Comment Sheet
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The laws and regulations which guide the weapons acquisition process require every program manager to use competition whenever it is feasible and effective to do so. Although the emphasis historically has been or competition during the early phases of the acquisition cycle, the Department of Defense also stresses the importance of competition in production. The program manager must assess the feasibility and effectiveness of production competition in a highly detailed, rigorous, and quantitative way.

These circumstances have led to the development of a production competition handbook. The purpose of this handbook is to provide the program manager and other acquisition officials with a systematic guide to the assessment, implementation, and execution of production competition. The various techniques for establishing competitive production sources are described along with two models to aid the manager in deciding whether or not to pursue production competition on a specific program.

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